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War has created a tremendous demand for dried foods

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MORE "STAYING POWER"

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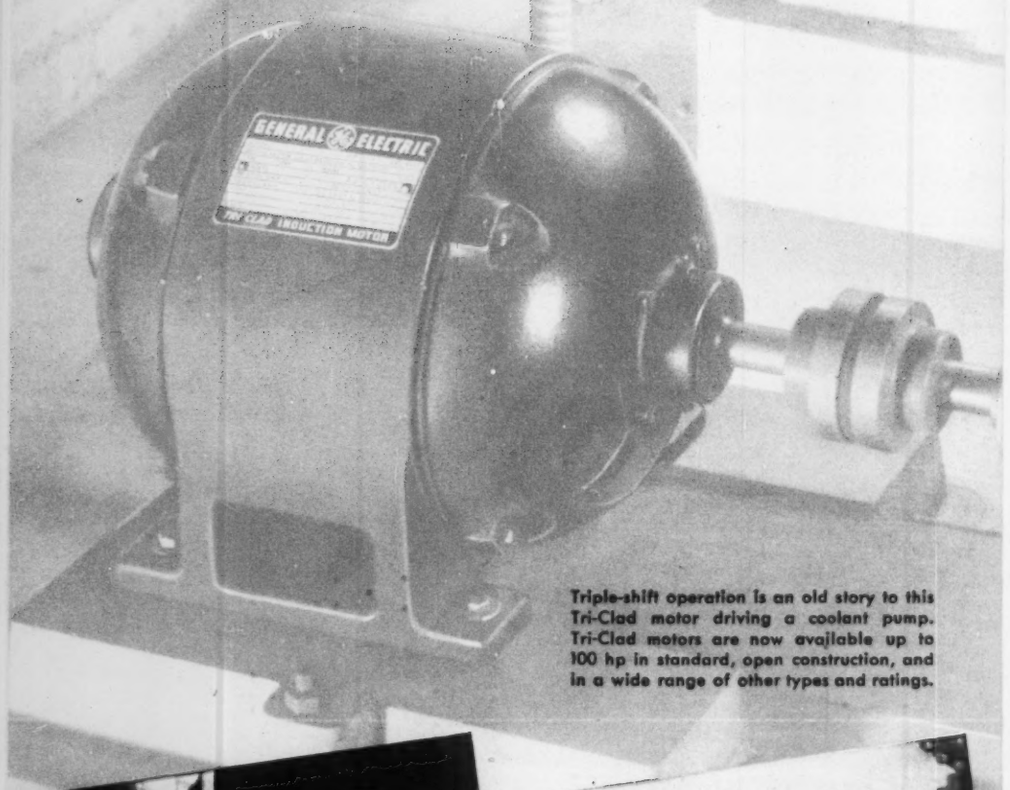

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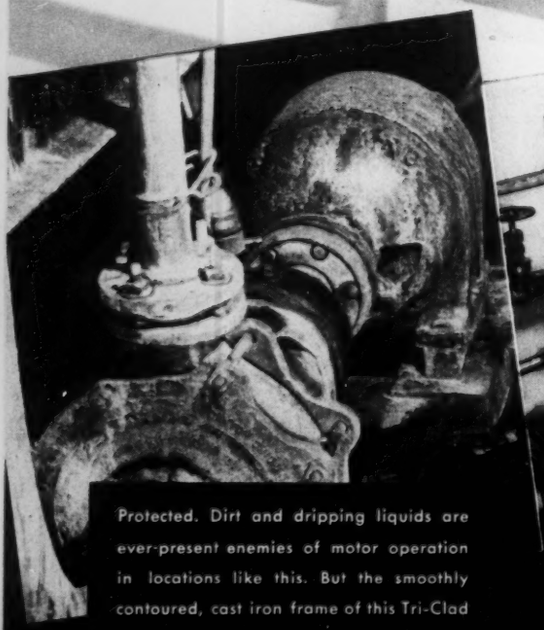

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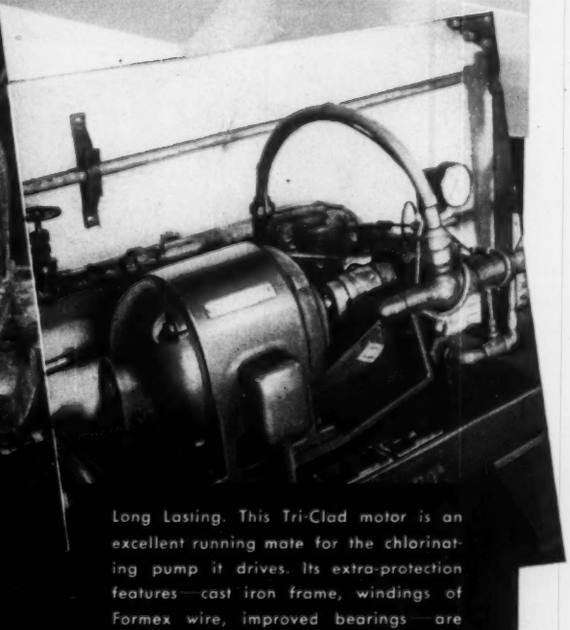

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[*Front cover photo*—Aboard a cruiser in the South Pacific, during loading of supplies. The war has created a tremendous demand for dried foods to supply our armed forces and our allies. The first of several articles on the drying of foods is published this month. (Official U. S. Navy photograph)]

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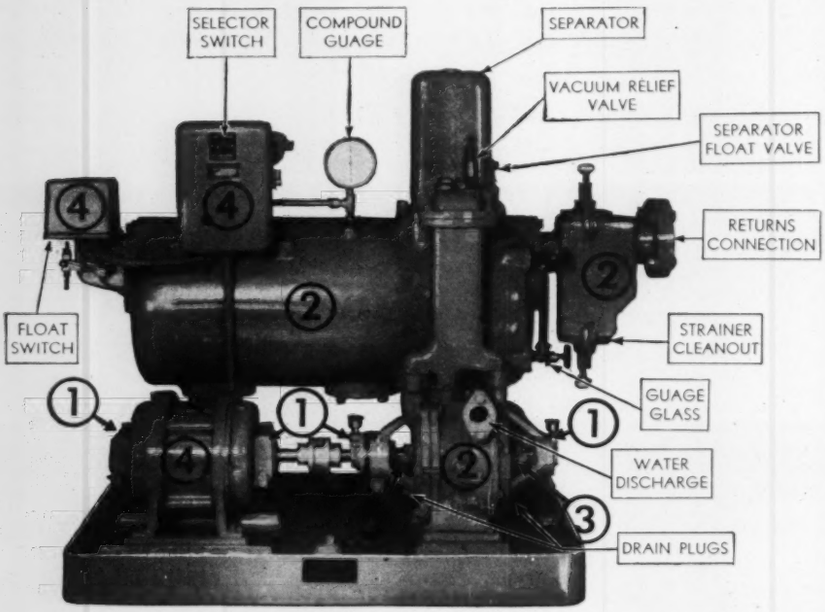
GENERAL ELECTRIC

How to keep your Jennings Heating Pumps in First Class operating condition for Duration...



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THE DRYING OF FOODS

War Creates Tremendous Demand for Dried Foods to Save Shipping and Storage Space, Prevent Spoilage . . . . . W. R. Marshall, Jr., Describes the Many Problems Involved

SUMMARY—The importance of food drying has predominated in times of war, present practice in the field having received its development and expansion during the Boer War and World War I. The great need for large supplies of concentrated foods for our armies and those of our allies—and our civilian allies—has created a tremendous demand for dried foods. . . . There is a big field for more engineering attention to food drying problems, and heating, air conditioning, and piping are all involved. For this reason, HEATING, PIPING & AIR CONDITIONING presents in a group of articles—of which this is the first—a comprehensive and practical review of food drying today. The author has specialized in the subject of drying, and is connected with the technical division of the engineering department at E. I. du Pont de Nemours & Co.

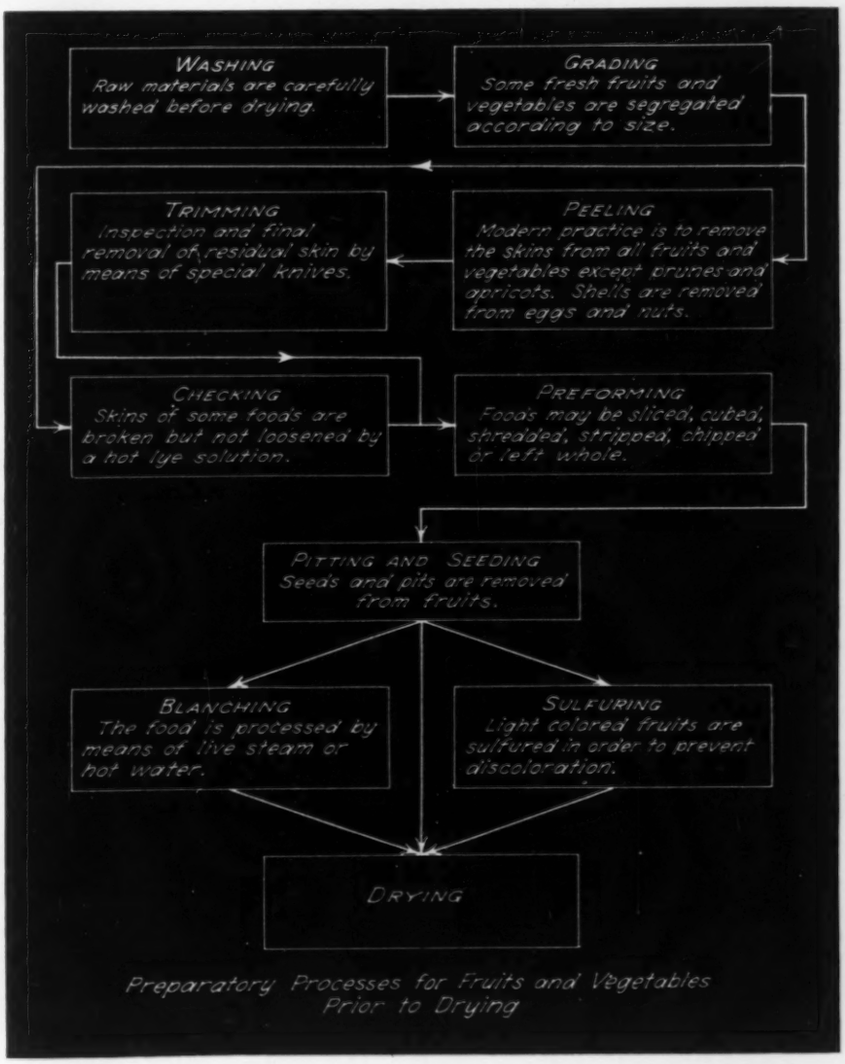
THE GREAT need for large supplies of concentrated foods for our armies, for the armies of our allies, and for our civilian allies in other lands has created a tremendous demand for dried foods. Curtailment of materials necessary in the production of canned goods likewise has served to increase the importance of drying as a means of preserving food supplies.

The drying of foods has many advantages, though there are still problems to be solved in connection with the preservation of the vitamin content and the flavor of the dried product (3,17)*. Much has been done in the past 20 years to improve the quality of dried foods. In the early stages of food drying, the product was often not only unpalatable and off-flavor but during drying and storage it readily lost much of its vitamin C and carotene content. Extensive research has been done in an effort to eliminate these undesirable results, and today dried foods not only retain a higher percentage of the fresh food value, but after they have been reconstituted are palatable.

However, complete information is not yet available regarding the proper methods of preparing, drying, and storing foods. Briefly, it is known that certain enzyme deactivation must occur before drying if the dried food is to be stored any length of time, and it has recently been found (17) that the vitamin C content of dried vegetables may be retained better if they are stored in the absence of air. Storage in an inert atmosphere, such as nitrogen or carbon dioxide, would also probably aid in retaining the carotene content.

Much could be written about food drying and its ramifications. This discussion, however, will deal primarily with the drying operation and its engineering aspects, and only secondarily with the processes prior and subsequent to drying. The important phases of food chemistry and nutrition and their relation to the study of and research on food drying must of necessity be considered elsewhere.

A picture of present engineering practice in food drying will be presented in several articles. First, we will deal with methods of preparing foods for drying, general characteristics of the drying operation, and the kinds of drying equipment suitable for food drying. Next, we will consider the fundamentals of drying and their application to the proper design and operation of food dryers.


WASHING
Raw materials are carefully washed before drying.
GRADING
Some fresh fruits and vegetables are segregated according to size.
TRIMMING
Inspection and final removal of residual skin by means of special knives.
PEELING
Modern practice is to remove the skins from all fruits and vegetables except prunes and apricots. Shells are removed from eggs and nuts.
CHECKING
Skins of some foods are broken but not loosened by a hot lye solution.
PREFORMING
Foods may be sliced, cubed, shredded, stripped, chipped or left whole.
PITTING AND SEEDING
Seeds and pits are removed from fruits.
BLANCHING
The food is processed by means of live steam or hot water.
SULFURING
Light colored fruits are sulfured in order to prevent discoloration.
DRYING
Preparatory Processes for Fruits and Vegetables Prior to Drying

*Numbers in parentheses refer to references at end of this article.

Reasons for Drying Foods

The importance of food drying has predominated in times of war. Present practice in the drying of foods received its development and expansion during the Boer War and the first World War. The significance which Germany has attached to the drying of foods was reflected in a food drying symposium held in December, 1940. A brief summary (8) of the 12 papers delivered at this meeting serves to indicate the extent to which food drying is being utilized and investigated in that country.

One of the chief reasons for drying foods, at the present time, is to reduce their weight and volume for shipping and storage purposes. Some idea of the reduction in the weight of vegetables after they have been dried may be gathered from the accompanying table (14). It is apparent from these figures that marked economies in shipping can be effected by drying foods that are to be transported great distances, and with the present demands on ships and ship space these figures assume added significance.

One of the most striking examples of the reduction of weight and volume for shipping purposes is the case of dried milk. A quart of fluid milk weighs about 34.4 oz; when dried to a powder, its weight is 3 oz and it occupies a volume of about three-fourths of a cup. Roughly, 1 lb of milk powder will furnish 5 qt of reconstituted milk. Dried milk must be properly packaged because of its hygroscopic character in the powdered form.

Another equally important reason for reducing the moisture content of foodstuffs is to prevent spoilage and decomposition during storage. Essentially, foods spoil because of the growth of molds and bacteria. By reducing the water content to low percentages, the water soluble solids may be concentrated sufficiently to prevent further bacteria and mold activity. Drying, however, does not necessarily prevent the action of enzymes, which are present in all foodstuffs, and since these bodies are capable of changing the composition, color, and flavor of foods after drying, special attention must be given to them in connection with the drying problem.

Foods are also dried when the total amount of food on hand is too small to be preserved economically by canning, or when drying is a step toward further processing.

Equally as important as fruits and vegetables in the field of food drying are the energy and bone building substances, such as meats, eggs, and milk. The physical state of eggs and milk requires drying methods and equipment which differ radically from those used in drying solids. An incomplete list of other foods which may be dried includes baking powder, beef extracts, beverage powders, butter, candy, casein, coconuts (shreds), fish, garlic, gums, hops, malt extract, noodles, nuts, pectin, salt, soups, spaghetti, starch, sugar, wheat, and yeast.

General Operations Prior to Drying

There are certain preparatory and pretreatment processes prior to drying which are of a general nature for most kinds of fruits or vegetables, and for certain other foods. These prior processes are briefly presented herewith in the form of a flow sheet, which is intended to depict the material as it proceeds toward the drying operation. Knowledge of these processes is important in any layout problem, and the drying operation is often greatly benefited by a proper arrangement and understanding of the processes preceding it.

In most cases the pretreatment operation and its purpose are self-explanatory. However, a few comments should be made with regard to the operations of blanching and sulfuring.

The purpose of blanching was intimated previously when it was noted that drying alone does not always prevent enzymatic action from spoiling stored fruits and vegetables. In order to inactivate the enzymes so that they will not continue to catalyze decomposition processes after drying, the process of blanching is used prior to drying. This process consists of applying live steam, or in some cases hot water (190-212 F), directly to the fruit or vegetable. Blanching may be performed directly in the dryer itself or as a continuous operation prior to drying. Blanching in the dryer is not especially desirable because no means of washing after blanching can be used. In addition, corrosion will be a significant problem. Hot water blanching is undesirable because it tends to dissolve valuable minerals and water soluble vitamins. It is the blanching process which has made the drying of vegetables feasible and economical during the past 10 years (2).

Sulfuring is an operation designed to prevent the discoloration of light colored fruits such as apricots, peaches, pears, apples, and sometimes grapes and figs. In addition to preventing discoloration, sulfuring also causes the cell membranes of the fruit to become permeable to water, thus facilitating the movement of the water through the fruit to the surface of drying. Sulfuring is carried out in an enclosed chamber in which sulfur is burned in shallow pans to furnish large quantities of sulfur dioxide.

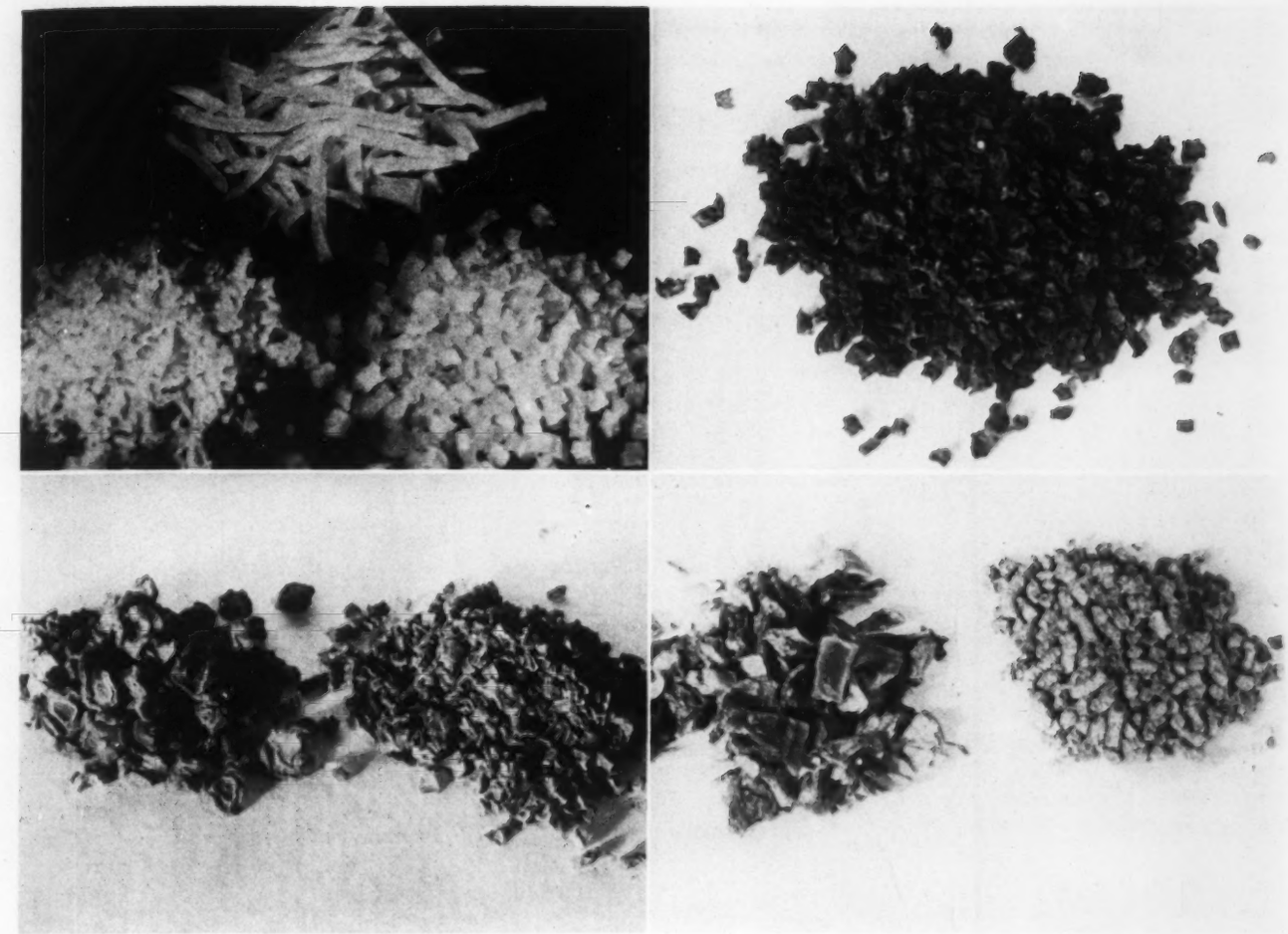
For further description of these operations prior to drying, with special reference to specific fruits and vegetables, the work of Cruess (7) is recommended, and also the recent publication of the U. S. Department of Agriculture by Chace, Noel, and Pease (4).

In the drying of milk, special preparatory measures are generally not required, although recent studies of Jack and Henderson (9) indicate that certain types of treatment improve the quality and prolong the keeping time of whole dried milk.

One of the most recent innovations in food drying brought about by World War II is the production

Reduction in Weight of Vegetables by Drying

Vegetable	Weight Prior to Drying, Lb	Weight After Drying, Lb	Per Cent Reduction of Original Weight
Corn	100	62.0	38
Peas	100	18.0	82
String beans	100	13.3	86.7
Lima beans	100	31.2	68.8
Tomatoes	100	11.4	88.6
Pumpkin	100	14.3	85.7
Sweet potatoes	100	35.5	64.5
Cabbage	100	14.8	85.2



Product	Method of Preforming or Subdivision	Average Particle Size Before Drying	Temperature of Drying Air* F	Drying Time--Hr (Test Time to Final Moisture Content)	Initial Moisture Content, Per Cent, Bone Dry Basis	Final Moisture Content, Per Cent, Bone Dry Basis
UPPER LEFT	Cubed or Diced	1/4 in. cube	200-160 DB 120-95 WB	2	437	7
Potatoes (Idaho)	Stripped (Julienne Style)	1/4 in. sq x 3/4 to 2-1/2 in. long	200 DB - 120 WB 160 DB - 95 WB	4.5	435	5
	Riced	1/8 in. diam.	200 DB - 120 WB 160 DB - 95 WB	0.93	400	5
LOWER LEFT Carrots	Sliced	1/4 in. thick x 1-1/2 to 2 in. diam.	180 DB - 120 WB 160 DB - 90 WB	3.35	559	5
	Cubed or Diced	1/4 in. cube	180 DB - 120 WB 160 DB - 80 WB	2.25	617	5
UPPER RIGHT Beets	Cubed or Diced	1/4 in. cube	180 DB - 120 WB 160 DB - 95 WB	2.5	570	5
LOWER RIGHT Chicken	Chopped	Irregular pieces 1/2 in.-3/4 in. thick	150	3.6	164	7.5
	Ground through 3/16 in. holes	3/16 in. extrusions	150	1.0	170	3

*Two different temperatures are involved in some cases, since in through-circulation drying it is possible to control the drying temperatures at various points in the drying process and in the dryer; e.g., in the initial stages higher temperatures may be used than the permissible final drying temperature.

of concentrated orange juice. This process is being performed by a plant in Florida. The product is said to resemble a yellow or orange jelly which is about 13 times as concentrated as naturally occurring orange juice. It is produced under vacuum and at low temperatures, which is one of the methods currently used for drying blood plasma. It is claimed to cost the consumer one cent per ordinary size glass.

Certain preliminary preparations are necessary in the drying of eggs, depending upon whether the yoke and albumen are to be dried separately or together. The methods and standards for drying eggs have been outlined by Mulvany (12).

Lemons may be dried to a powder which is then mixed with a sugar, such as corn sugar. When water is added to the mixture, a close approximation to the original juice is obtained.

In drying butter, it is necessary to melt it first. Drying is then performed under vacuum to remove dissolved gases in order to prevent subsequent oxidation. By adding water and salt to the dried butter, a reconstituted product is obtained which is suitable for table use.

Prior processes in the drying of meats consist mainly of subdividing and trimming. However, research is now under way in an attempt to solve the problem of drying large

pieces of meat, such as whole sides of beef. The meats dried at the present time are primarily beef and pork. The method of drying as specified by the American Meat Institute is essentially as follows: The meat is first ground, and then precooked for at least 30 min at not less than 165 F. The precooking is virtually a blanching process at a low temperature. Its purpose is to preserve the general nutritional value of the meat. After precooking the meat is air dried (sometimes vacuum dried) at temperatures of 140-170 F. The dried, ground meat is generally used for meat loaves, stews, patties, etc.

General Characteristics of Food Drying

Because food drying has assumed such large proportions*, the actual drying process should necessarily receive much attention, and this operation—which once was done in small, batch, "home made" dryers without regard for controlled conditions—must of necessity now be performed in large scale, semi-continuous, and continuous dryers with automatic controls. However, there is still a big field for engineering attention to food drying methods.

Terminology

Some writers (4, 5) have chosen to distinguish between the terms drying, dehydration, sun drying, and evaporation as applied to the removal of moisture from foods. Strictly speaking, drying is a generic term for the removal of moisture or other liquids from materials when thermal means are employed. Because it would be possible to classify under this definition of drying large scale evaporation operations such as those involving single or multiple effect evaporators, it is necessary to define drying further on the basis of the type of equipment used. Thus, drying implies the removal of moisture by thermal means in equipment designated as dryers.

*In 1937, nearly 1200 million lb of fruit valued at $62,000,000 were dried in the United States. Since June, 1941, the capacity for drying eggs has risen from 10 to 290 million lb per yr. The U. S. sent to Britain 200 million lb of dried milk between April, 1941, and June, 1942, and plans are under way to increase this production several fold. Only dried vegetables appear to lag, although the Army is demanding several hundred times the 2 million lb it purchased up to July, 1942.

Dehydration and sun drying are special cases of the drying process. In chemical terminology, dehydration means the removal of water of crystallization and water of hydration; i.e., water that is chemically bound with the materials. The removal of chemically bound water often requires temperatures considerably in excess of those encountered in the drying of foods. Evaporation and vaporization are concomitant processes with any drying operation, and hence should not be used to define the drying process.

Drying Temperatures

It may be quite generally stated that food drying as performed to date is a low temperature operation, the temperature of the drying medium seldom exceeding 170 F, with the material temperature generally remaining lower than this. The chief reason for temperature limitations in food drying is that food decomposition occurs above certain temperatures. Another important reason lies in the phenomenon of so-called "case hardening" of the surface of the food. Case hardening is essentially the formation of a hard, dry, surface layer on the food, and it results indirectly from the high temperatures used. Case hardening tends to decrease the rate of drying.

In the case of drying seed corn, it is important to dry at low temperatures to prevent the destruction of the germinating ability of the corn. Moderate temperatures, however, coupled with high humidities are very conducive to mold growth. It is true that in some cases moderately high air temperatures (200-220 F) may be used at the start of the drying process when the material is sufficiently wet on the surface so that it is maintained cool by the wet bulb cooling effect of the air passing over it. (This point will be considered in more detail later.) Toward the end of the drying, the food approaches the air temperature, which must then be lowered to some critical temperature determined by the character of the food being dried. Mangels and Gore (11) have classified vegetables as to their relative sensitiveness to temperature.

In some types of dryers it is possible to use higher air temperatures than in others. Thus, in spray dryers the drying air may be as hot as 250 to 300 F without affecting the material being dried. In the continuous, through-circulation dryers, higher air temperatures may be used initially because such dryers are designed so that the temperature may be accurately controlled to conform to all stages of drying. More will be said about this later.

Initial Moisture Content

In all foods, water represents a large percentage of the total weight. This percentage may range from 67 per cent (wet basis) in fruits such as prunes to 95 per cent (wet basis) in vegetables such as spinach and celery. Water in foods will be in both a free and a combined state. "Free water" is defined as that water which exerts its normal vapor pressure at the temperature and pressure under consideration. Combined water exerts a vapor pressure which is less than the normal vapor pressure of water at the same temperature and pressure. In general, free water is removed during the first stages of drying, followed by the removal of combined water. The combined water in foods will generally be held in cells and cell walls, so that its movement to the surface of drying will be governed primarily by the rate at which it can pass through the cellular structure of the particular food. The rate of moisture movement within the food is the controlling factor during the final stages of drying.

A word should be said here about the basis for specifying moisture content. It will be noted that a wet basis, lb of water per lb of wet food, was used above. This is not always desirable, however, and it is more meaningful to express all moisture contents on a dry basis, lb of water per lb of dry food. The reason for this may be made clear by the following: If a food has an initial moisture content of 85 per cent on the wet basis and this percentage is likely to vary over a range of plus or minus 2 per cent, a serious fluctuation in heat load will be experienced by the dryer. This is not at once evident. However, assume the dryer to be producing 1000 lb per hr of bone dry food. Consider the final mois-

ture content to be 5 per cent. At 85 per cent initial moisture content, the water evaporated is about 5620 lb per hr. Now if the initial moisture content on the wet basis should increase to 87 per cent, then the evaporating load will become 6650 lb per hr, an increase of 1030 lb per hr. Thus, at high moisture contents an increase of 1 or 2 per cent moisture content on a wet basis is very significant. The use of the dry basis, however, is not misleading, since the percentages are directly additive in this case. It is important to realize also that the initial moisture content of like products varies with the seasons and geographical location.

Some examples of the range of initial moisture contents expressed as lb of water per 100 lb of bone dry food, or as per cent moisture, dry basis, are: potatoes, 390-450; cabbage, 900-980; carrots, 550-630; beets, 570-650, and turnips, 750-820.

Final Moisture Content

The final moisture content of dried foods is of extreme importance with respect to keeping qualities. It should be uniform and low enough to inhibit undesirable microbic action within the food. Dried foods with a sufficiently low moisture content are not readily attacked by insects. It is therefore apparent that a low final moisture content is extremely desirable, and although it involves a longer drying time, nevertheless the advantage of increased keeping quality afforded by it more than offsets the disadvantage of decreased capacity. For fruits high in sugar content, the final moisture content should be not over 15 to 20 per cent. For other fruits and vegetables, the allowable final moisture content is 5 to 10 per cent, preferably in the lower range.

In general, the residual moisture in dried foods will be bound water, and in air drying the final moisture content will depend upon the relative humidity of the air. Foods cannot be dried below the equilibrium moisture content corresponding to the temperature and humidity conditions of the drying air. The equilibrium moisture content of a material may be defined as that moisture content which is in a dynamic equilibrium with the moisture in air of a specified humidity and temperature. The equilibrium moisture content increases with increasing humidity and decreases with increasing temperature. A plot of per cent equilibrium moisture content vs. per cent relative humidity gives a characteristic S shaped curve for many materials. At normal conditions of temperature and humidity, foods may retain 3 to 10 per cent moisture, which is in equilibrium with the surroundings. Only by using bone dry air is it possible to dry foods completely.

Form of Food for Drying

Food to be dried is generally preformed by the previously indicated operations of shredding, slicing, chopping, cubing, etc. In some instances it may be dried whole, as in the case of prunes, grapes, corn, peas, etc. In a subdivided condition, the food automatically aids the drying process by affording a large surface area for evaporation. Probably the most outstanding example in which subdivision of the material speeds up the drying rate is in spray drying. In this case, a spray of the liquid contacts hot gases and the enormous surface offered by the particles makes drying a matter of but a few seconds. The initial and final forms of the food are important in selecting the type of dryer to be used.

Appearance of Dried Foods

In general, dried foods take on a shriveled or shrunken appearance. Dried milk and eggs, of course, are in a powdered form. Orange juice which is not completely dried possesses a jelly-like appearance. In the drying of oysters, a process now being developed in this country, the dried oysters have an extremely shriveled appearance. They weigh about 1 per cent of the wet weight and occupy about 15 per cent of the wet volume.

In the accompanying photographs are shown dried vegetables and chicken. These products were dried in the research laboratories of Proctor & Schwartz by the method of through-circulation, which has been described in detail by Marshall and Hougen (11a). This method permits close control of air temperature, and affords rapid and uniform drying.

[The author wishes to thank H. G. Black, A. O. Hurxthal, and R. M. Ireland, all of Proctor & Schwartz, Inc., for their help, advice, and suggestions, and for the release of drying data on foods.]

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Fuel Conservation -- Always Good Business -- Becomes Wartime "Must"

What YOU Can Do to "Keep 'Em Heating" and Still Save Fuel

. . . . . By Eph. A. Tyler

SUMMARY—Suppose the government restricts your maximum fuel allowance to the equivalent of 0.6 pounds of steam per one thousand cubic feet of building volume per degree day? Could you keep your tenants comfortable? . . . . That wouldn't be unreasonable, for many buildings do better. An order of that nature would give consideration to the present efficiency of each building, and wouldn't penalize the efficient ones—as would rationing on the basis of former consumption. . . . Here's an easy-to-read, practical discussion of how to reduce fuel consumption for heating, written by a man who has had a lot of first-hand experience and has saved many pounds of steam by the methods he's talking about. . . . Mr. Tyler's title is rental manager of the First National Bank Building (St. Paul) and he is a member of HPAC's board of consulting & contributing editors. Mr. Tyler keeps on intimate terms with the boiler room, and is here seen inspecting gages and control graphs

THE DECADE preceding 1940 called for shrewdness and ingenuity on the part of the operators of our great office, institutional, and loft buildings, in the use of fuel for heating, and the "defense era" before Pearl Harbor was a clear signal to batten down the hatches and get ready for the storm. Now, the storm is upon us and many will find that they are compelled by the force of circumstances to cut their fuel consumption by 10 to 30 per cent; even a greater cut may be in the offing if the U-boats continue their depredations. While this condition at present applies mainly to the eastern seaboard, there is a fair likelihood that other areas will be affected, if and when the war goes into the second and third years, through inability of the railroad, barge, and boat lines to deliver normal fuel supplies in addition to necessary war materials.

Can these requirements be met without stoppage of work or suffering of the occupants of these buildings? I believe they can in at least 75 per cent of the buildings and without the use of critical materials in excess of WPB allowances for maintenance. Recent surveys by a joint committee of the National District Heating Association and the National Association of Building Owners and Managers have shown that most buildings are using from 10 to 50 per cent more fuel than necessary, and it is not unusual to find some buildings using three times more than the most efficient.

Just Suppose

Just to put the problem on a "blood, sweat, and tears" basis, let us assume that the government issues tomorrow, under it war powers, an order that: "Beginning October 1, the maximum fuel allowance for space heating of office, loft, institutional, apartment, and public buildings shall be the equivalent of six-tenths (0.6) of a pound of steam per one thousand cubic feet of building volume per degree day. Measurements shall be the cubic contents of heated, occupied rooms. The government weather bureau reports giving heating degree days

Radiator traps need periodic checking, cleaning, and repair

shall be official for that measurement." That would not be an unreasonable order, for to my knowledge there are a fair number of buildings doing 30 per cent better than that. No doubt you would be required to register your building the same as your family is now required to register for sugar, and under oath give the heated cubic contents of your building or buildings, the amount of fuel on hand, and the heating degree days in your locality last year. You might be allowed 70 to 80 per cent of the fuel consumed the first four months last year to give you time to "batten down the hatches," and after that you might be held to a definite measure of fuel per thousand cubic feet per degree day. If you have already equaled or bettered the equivalent of 0.6 lb per 1000 cu ft per degree day, you wouldn't have much to worry about, but if you haven't, don't wait for a "Pearl Harbor."

You will see by the foregoing that I am hoping that any government rationing of fuel will give consideration to the present efficiency of each building, for it would be manifestly unfair to ration on the basis of a percentage of former consumption. A building with a consumption of 1.2 lb of steam or equivalent fuel (and there are plenty of them) when cut down 30 per cent could, by stepping up efficiency, meet that requirement easily and would, in fact, be rewarded to the tune of 30 per cent of their fuel costs for their trouble; while a building with a consumption of 0.4 lb (and there are a few of them) is probably near the "rock bottom" of fuel consumption. To cut the latter building 30 per cent would leave but two alternates—to close off part of the building, or reduce the temperature to a point where it might be extremely hazardous to the health of the occupants, not to mention their comfort.

Oversize Plants

Most of you who read this well know, I am sure, that a heating plant is designed for the most extreme condition, but it is amazing how many of us forget this simple fact. If your automobile engine was running at top speed to push your car 30 miles per hour, you would do something about it quickly. But there is many a heating plant with serviceable controls disconnected and unused, perhaps unknown to the management. So I would say that the first step to meet the fuel cut is to look to the controls—fuel supply, boiler feed, and steam feed. They should be brought to the highest state of efficiency. Needed repair parts costing not over $50 may be purchased through established heating contractors under WPB order P-84.

Much can be done, too, through a re-training program for your boiler room personnel. Management had better put on a pair of coveralls and spend a few hours in the boiler room every day until it can be certain that it has a white plume at the top of the stack at all times when the boiler is in operation, for black smoke means waste. If your office is not already where you can see the stack, it had better be moved where you can, or arrange a mirror gadget so that you can see it without turning your head. Without mechanical controls, an effective job can be done only by the best use of the skill you have, plus eternal vigilance.

Stop Leaks

If air were visible, the problem of stopping leaks of good, heated air from buildings would be comparatively simple; being invisible, it requires the exercise of considerable ingenuity effectively to stop unnecessary leaks—and these are one of the greatest sources of wasted fuel. In high buildings particular attention should be given to the top of the building—are the windows as tight as can be made, do the doors fit snugly (perhaps an extra door on that pent house would seal it tight)? If the windows in the building are not as snug as operation will permit, the employment of a first class weatherstrip carpenter to go over them all and do the best job possible will more than pay his cost; incidentally, make needed repairs to the weatherstripping if you can get the metal. Refelt all revolving doors and be sure that your swing doors are not blasting an undue dose of frigid air into the building.

Mechanically ventilated buildings in the northern part of the United States sometimes represent one of the worst sources of wasted fuel. Most outside air intakes are closed with metal dampers that are supposed to stop the cold air intake when the fans are not running—but often they don't. Dampers can be put in first class condition and made as tight as possible, and if the urgency is great enough, heavy

canvas on frames or plywood auxiliary doors can be fitted to the outside air intakes and operated manually. Dead stopping these openings when fans are not running will save 20 to 40 per cent of the steam consumed by heaters and reheaters.

Circulation

Without free circulation in all mains, risers, and returns, even though you have that white plume at the top of the stack, you are a long way from getting the best efficiency from your plant. A regular schedule for cleaning drip and radiator traps should be set up and rigidly enforced, and a proper system of accounting for this important work should be provided in the form of written reports. There is a vast difference in boiler feedwaters and quality of central station steam. One type of water or steam may require monthly cleaning of the drip traps and quarterly cleaning of radiator traps, while a better quality may require but an annual or semi-annual cleaning. The frequency of cleaning must be determined by actual conditions.

The pipes in many old heating plants have become so filled with oxide of iron and sludge that it is not uncommon to find them operating at 25 to 40 per cent below a fair efficiency level. In one large building under my supervision (nine years old, at the time) an examination of a few return lines indicated a considerable accumulation of sludge. This was a welded pipe job, and it appeared that the welding process had left a considerable quantity of welding iron particles inside the pipe. These particles had mostly oxidized away and the oxide of iron had combined with the small amount of oil condensed in the pipes. This sticky sludge had commenced to give us trouble with the radiator traps, requiring unduly frequent cleaning.

Sludge Removed

At the time I did not feel that this sludge condition had advanced to a point where it impaired efficiency, as our steam consumption for that building was then down to 0.467 lb, but the labor cost of cleaning drip and radiator traps was getting to be excessive and I felt that there was trouble building up there. About that time a salesman called on me, offering a proposition to clean the entire piping system and guaranteeing that the piping should be entirely cleaned of all oxide of iron, oil, and sludge, and without injury to the pipes. Careful investigation convinced me that the proposition had merit, although it was new at the time, and I let the job. In his selling arguments, he steadfastly maintained that the cleaning process would save us a substantial volume of steam, but at the time I did not believe that it would as the building was comparatively new and our steam consumption there was about as low as I thought it ever could be. I watched with interest as the work was done and was amazed to find that, when finished, over 10 bushels, dry measure, of solids had been removed from the mains and returns, and I don't know how much oil. A 1 gal glass jug filled with effluent the first day they started flushing contained about 10 per cent solids, 20 per cent oil, and the balance water.

Since I did not expect any economy in fuel consumption from this operation, I was pleasantly surprised at the end of the following heating season to find that consumption had declined 10 per cent under the preceding season, calculated on a degree day basis. I mention this incident to show how important it is to keep the piping, radiators, and traps free from insulating, circulation-retarding sludge.

Accounting

Even the smaller plants consuming under $1000 worth of fuel per year should have some systematic method of recording fuel consumption and the temperatures, but the larger the plant the more important it is to keep such data for comparative purposes. The weather bureau puts out a monthly report of the weather in key communities throughout the country. This report will be mailed to anyone every month without charge upon application to the nearest weather bureau station. It gives the daily high, low, and mean temperatures, the total degree days for the month, and many other interesting and useful facts about the weather.

If the weather bureau thermometers are too far from your building to be sufficiently accurate for your purposes, it may be profitable to set up your own recording thermometer and compute mean temperatures right at the building. If you cannot buy a recording thermometer, mean temperatures can be calculated from any good thermometer by taking readings every four hours. Add the totals and divide by six; the result is the mean temperature for that day. Mean temperature subtracted from 65 gives the heating degree days for that day.

How Good Are You?

I have my own system for marking different buildings on their efficiency in fuel consumption. It is based on pounds of steam or equivalent fuel consumed per thousand cubic feet per degree day. Here it is. A little work with a pencil and a weather bureau report, and you can mark yourself:

0.4 lb, excellent. 0.5 lb, good. 0.6 lb, fair. 0.7 lb, medium. 0.8 lb, poor. 0.9 lb, bad. 1.0 lb, terrible. 1.1 lb, do something drastic. 1.2 lb, fire the whole boiler room gang and give the whole plant the works.

I have not forgotten boiler operation. That is a whole story in itself, and has been covered in these pages recently by better men than I am.

Assistant Chief Engineer Warner Paddock checks temperature of condensate return, which is an important gage of efficiency

FAN LAWS--Their Derivation and Use

Thorough Understanding of Fan Laws of Great Value to Users, Permits Selection for Efficient Operation . . . By William Goodman

SUMMARY—A thorough understanding of the fan laws can be of great value to the user of fans. The fan laws can be of help in selecting fans so that they operate at their most efficient point and in determining the effect of changes in fan speed. Important in many cases is the effect of changes in the density of the air that the fan is handling. All fans are rated in terms of standard air, the density of which is 0.075 lb per cu ft. . . . . Although the effect on fan performance with changes in air density can frequently be neglected, there are many cases where these effects should be taken into account. It has been the author's experience that the fan laws dealing with changes in density are particularly likely to be misapplied. In the article of which this is the second part, a clear explanation is given of the proper application of the fan laws and their use is illustrated with examples. . . . . Mr. Goodman is consulting engineer, The Trane Co., and a member of HPAC's board of consulting & contributing editors

THE FAN laws or relations presented in the August HPAC are the ones most commonly used. By means of them, almost any desired data can be computed for various fan speeds and sizes. However, occasionally special relations may be more useful for specific cases. These special relations can be derived by methods similar to those used last month. For example, by eliminating the ratio (N_2/N_1) between equations 9 and 15, a new relationship between the quantities, V, p, and D alone may be obtained.

To take another example, the equations given below are widely used for computing multirating tables of fan performance such as are commonly found in fan catalogs. They are derived from equations 15 and 21 as explained later.

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \text{.....[24]}$$

$$\frac{(hp)_2}{(hp)_1} = \left(\frac{D_2}{D_1}\right)^2 \quad \text{.....[25]}$$

These two equations are true only for one given static pressure and one outlet velocity. After a fan has been tested and the ratio curves like those in Fig. 2 [p. 488, August HPAC] computed, a performance table is computed for one fan size from the ratio curves. After the table has been computed for the fan size, the tables for all other fan sizes can be computed from this same table by means of equations 24 and 25. In most fan catalogs, the air quantities are based on a series of outlet velocities which are the same in each table for each different fan size. The static pressures listed are also the same for all the tables. Therefore, in each table for each different fan size, the values for the same outlet velocity and static pressure can be computed from the values in the first table by means of equations 24 and 25.

Example 2—Take the conditions of example 1 and find the speed and horsepower of a 33 in. geometrically similar fan when operating against the same static pressure of 5/8 in.

Solution—Using equation 24, $N_2 = 280 \times (30/33) = 255$ rpm. Using equation 25, $(hp)_2 = 2.03 \times (33/30)^2 = 2.46$.

Equation 24 is derived from equation 15, shown on p. 489, August HPAC. If the static pressures are the same, then equation 15 reduces to

$$1 = \left(\frac{N_2 D_2}{N_1 D_1}\right) \quad \text{.....[26]}$$

or

$$\frac{N_2}{N_1} = \frac{D_1}{D_2} \quad \text{.....[27]}$$

In any fan catalog, for the same outlet velocity and static pressure in all of the various columns of the different tables, the tip speed—the product of π times rpm times fan diameter—is constant.

Equation 25 is derived as follows: Equation 21 [p. 489, August HPAC] may be written

$$\frac{(hp)_2}{(hp)_1} = \left(\frac{N_2 D_2}{N_1 D_1}\right)^3 \left(\frac{D_2}{D_1}\right)^2 \quad \text{.....[28]}$$

However, from equation 26, $(N_2 D_2/N_1 D_1) = 1$. Hence, equation 28 reduces to equation 25.

The change in fan speed can be computed by means of equation 24 and the change in horsepower by equation 25. However, inasmuch as the fan diameter is changed while the static pressure is held constant, the cfm must also change. The cfm delivered by a larger fan can be computed simply by multiplying the constant outlet velocity by the outlet area of the new fan. The cfm can also be computed by the following formula.

$$\frac{V_2}{V_1} = \left(\frac{D_2}{D_1}\right)^2 \quad \text{.....[29]}$$

This equation is derived by writing equation 9 [p. 489, August HPAC] as

$$\frac{V_2}{V_1} = \frac{N_2 D_2}{N_1 D_1}\left(\frac{D_2}{D_1}\right)^2 \quad \text{.....[30]}$$

However, according to equation 26, $(N_2 D_2/N_1 D_1) = 1$. Consequently, equation 30 reduces to equation 29.

Example 3—Take the conditions of examples 1 and 2 and find the cfm that the 33 in. similar fan will deliver.

Solution—Using equation 29, $V_2 = 12{,}200 \times (33/30)^2 = 14{,}762$ cfm.

Symbols

D = diameter of fan wheel, in.;
d = density of air, lb per cu ft;
(hp) = horsepower;
N = fan speed, rpm;
p = pressure, in. of water;
U_p = peripheral velocity or tip speed, fpm;
V = volume of air per unit of time, cfm;
W = total weight of air delivered, lb per min

Operating Point of a Fan

The quantity of air that can be forced through a duct system varies very nearly according to the following law.

$$\left(\frac{V_2}{V_1}\right)^2 = \frac{p_2}{p_1} \quad \text{.....[31]}$$

If the pressure loss is known for one air volume, the pressure loss for any other volume can be approximated very closely by means of equation 31.

Curve 1-2 of Fig. 4 has been drawn by means of equation 31 from the known pressure loss at one given air volume. A curve such as 1-2 may be called the *character-*

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istic curve of the duct system. If the fan whose characteristic is represented by curve *A* is connected to the duct system whose characteristic is represented by curve *1-2*, obviously, *1*, at the intersection of the two curves, represents the point at which the fan will operate. In other words, the quantity of air delivered by the fan through the duct system and the static pressure against which it will operate is read at point *1*. On the other hand, if another fan whose characteristic is represented by curve *B* is connected to the same duct system, the air delivered through the duct and the static pressure against which the fan will operate can be read at point *2* of Fig. 4.

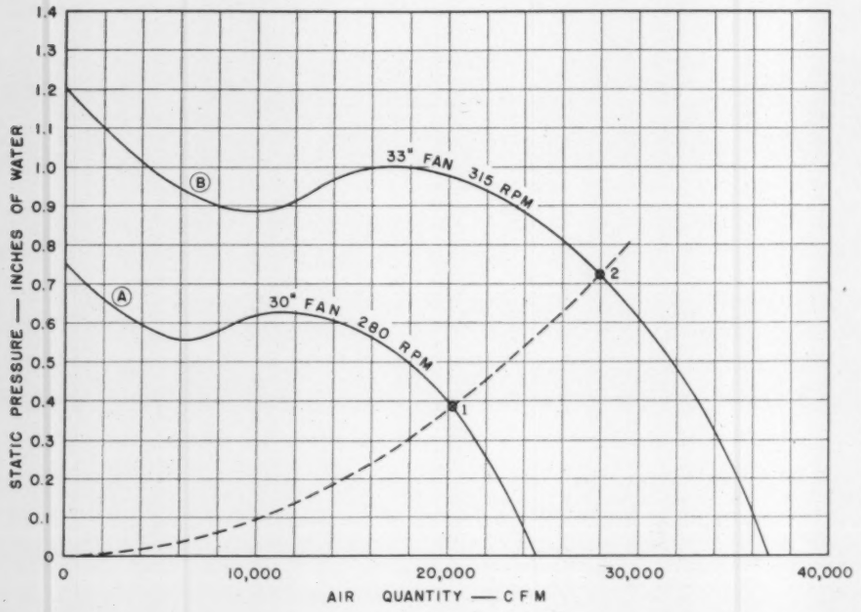


Fig. 4—Determining the point at which different size fans running at different speeds will operate when connected to a given duct system

Volume of Air to Be Delivered

For conditioning any space, the *weight* of air to be circulated through the space is of primary importance—not the *volume* of air. A certain *weight* of air is required to absorb a given amount of heat and moisture. Regardless of variations in its density, this same weight of air will absorb the same amount of heat and moisture for a given change in its total heat and dew point temperature. On the other hand, the same *volume* of air will not always absorb the same amount of heat and moisture for a given change in the total heat and dew point temperature of the air; the smaller its density, the smaller the amount of heat and moisture that a given volume of air can absorb. Furthermore, as the air is subjected to various conditioning processes, its volume will change but the weight of dry air in the air-vapor mixture will always be the same. Therefore, the weight of air is not only the most important factor, but also the most convenient one for computations because the weight of dry air is constant throughout the various conditioning processes.

However, when selecting equipment for conditioning air, the weight of air to be circulated must be converted into volume of air because all equipment is rated in terms of volume of air. But, the rating is always based on volume of *standard* air. Standard air is defined as air weighing 0.075 lb per cu ft. Hence, in selecting equipment, the weight of air to be conditioned must be converted into volume of *standard* air. For this reason, regardless of the actual temperature and humidity of the air, its actual density should be disregarded. Instead the value of 0.075 lb per cu ft should be used for determining the total volume of air upon which the *selection of equipment* is to be based.

It is surprising how rarely this point is clearly understood. Several published computations have been incorrectly based on the actual density of the air. This error leads to the incorrect selection of fan speed and horsepower.

Fan Speed Changes

Change of Fan Speed to Obtain Delivery of Required Weight of Air

A fan running at constant speed and delivering air through a given duct system—that is, a fan operating at a given velocity ratio—will always deliver the same volume of air regardless of the density of the air. Hence, the weight of air that a fan delivers varies with the density of the air. For example, a fan delivering 10,000 cfm will deliver 750 lb per min of air when handling standard air. On the other hand, if the density of the air is only 0.07 lb per cu ft, the fan will deliver only 700 lb per min even though it is still circulating 10,000 cfm. Consequently, if the density of the air differs from that of standard air and the fan must deliver a given weight of air, the total volume of air that the fan is circulating must be changed.

The total volume of air that a fan is delivering can be changed by changing the speed at which the fan is running. In other words, if a given weight of air must be delivered when its density differs from that of standard air, the fan speed must be changed from the speed at which the fan is rated in the catalog. The speed at which the fan must run in order to deliver the required weight of air whose density differs from that of standard air can be computed by means of the following equation:

$$\frac{N_2}{N_1} = \frac{d_1}{d_2} \quad \text{.....[32]}$$

This equation is derived as follows: If the weight of air delivered by the fan at either speed is to be the same,

$$W_1 = W_2 \quad \text{.....[33]}$$

$$V_1 d_1 = V_2 d_2 \quad \text{.....[34]}$$

$$\frac{V_2}{V_1} = \frac{d_1}{d_2} \quad \text{.....[35]}$$

Eliminating the ratio (V_2/V_1) between equations 3 [p. 489, August HPAC] and 35, equation 32 is obtained.

Example 4—A fan is to deliver 1542 lb per min of air. The actual density of the air that is being circulated is 0.07181 lb per cu ft. Find: (a) The volume of standard air for which the fan should be selected from the catalog. (b) The speed at which the fan must run in order

to deliver the required weight of air to the room.

Solution—(a) The volume of standard air is found by dividing the weight of air to be delivered by the density of standard air, disregarding the actual density of the air. Hence, $V = 1542 \div 0.075 = 20{,}560$ cfm, the volume of standard air for which the fan should be selected from the catalog. With the volume of standard air known, the speed at which the fan must run in order to deliver this volume of standard air can also be found in the catalog from which the fan is selected. Inasmuch as the speed when handling standard air must be known in order to solve part (b) of this problem, assume the catalog shows that the fan must run at 260 rpm in order to deliver 20,560 cfm of standard air.

(b) From part (a), $N_1 = 260$ rpm. Using equation 32, $N_2 = 260 \times (0.075/0.07184) = 271$ rpm, speed at which the fan must run in order to deliver 1542 lb per min of air whose density is 0.07184 lb per cu ft.

To maintain the weight constant, it is obvious from equation 35 that if the density decreases, the volume of air delivered by the fan must increase. After the fan is installed on the job, the volume of air that the fan will actually deliver when its speed is changed to compensate for a density lower than that of standard air can be computed by means of equation 35.

Example 5—Take the conditions of example 4 and find the volume of air that the fan will actually deliver.

Solution—From part (a) of example 4, the fan will deliver 20,560 cfm of *standard* air when running at 260 rpm. Also, from part (b) of example 4, the fan must run at 271 rpm in order to deliver the required weight of air. After the fan has been installed on the job, the volume of air that the fan will actually deliver when running at 271 rpm can be computed by equation 35. Hence, $V_2 = 20{,}560 \times (0.075/0.07184) = 21{,}465$ cfm.

Pressure When Fan Speed is Changed to Obtain Delivery of Required Weight of Air

If the speed listed in the catalog for standard air is corrected in accordance with equation 32, the required weight of air will be delivered to the room when the fan is handling air whose density differs from that of standard air.

If the fan speed is changed to compensate for the difference in density so that the desired weight of air will be delivered, the volume of air that the fan will deliver can be computed at the changed fan speed by means of equation 3 or equation 35 from the known air volume listed in the fan catalog.

In a later section, it is shown that regardless of the actual density of the air the friction loss in the duct system should be computed on the basis of standard air. The fan should be selected from the fan catalog not for the actual static pressure, but for the static pressure based on standard air. If the static pressure for standard air is known, the actual static pressure against which the fan will operate on the job can be computed by means of the following equation, which is derived later.

$$\frac{p_2}{p_1} = \frac{d_1}{d_2} \qquad \text{.....[36]}$$

Example 6—Take the conditions of example 4 and assume that the fan is to be selected to deliver 20,590 cfm of standard air against a static pressure of ¾ in. The required static pressure of ¾ in. has been computed on the assumption that standard air will flow through the duct system. Find the static pressure against which the fan will actually operate when handling air whose density is 0.07184 lb per cu ft.

Solution—Using equation 36, $p_2 = 0.75 \times (0.075/0.07184) = 0.78$ in., the actual static pressure.

In order to derive equation 36, the following equation, which is based on equation 12 [p. 489, August HPAC], may be written

$$\frac{p_2}{p_1} = \frac{d_2}{d_1}\left(\frac{U_{p2}}{U_{p1}}\right)^2 \qquad \text{.....[37]}$$

or, eliminating the ratio (U_{p2}/U_{p1}) by means of equation 14 [p. 489, August HPAC],

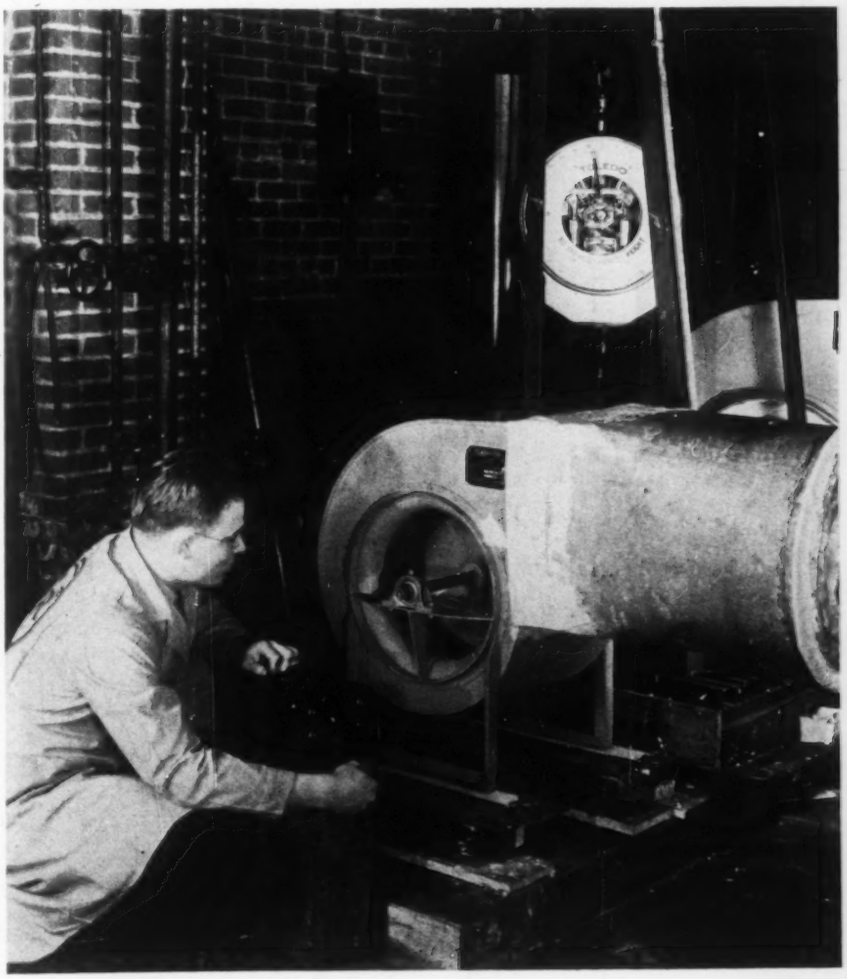
$$\frac{p_2}{p_1} = \frac{d_2}{d_1}\left(\frac{N_2 D_2}{N_1 D_1}\right)^2 \qquad \text{.....[38]}$$

However, for the same sized fan, $D_2 = D_1$. Hence,

$$\frac{p_2}{p_1} = \frac{d_2}{d_1}\left(\frac{N_2}{N_1}\right)^2 \qquad \text{.....[39]}$$

Eliminating (N_2/N_1) between equations 32 and 39, equation 36 is obtained.

A fan testing setup



Corrosion Tests of Soldered Joints on Copper Tubes

A. W. Tracy Reports Results of Studies Made Over One, Three, and Six Year Periods . . . Corrosion Shown to Be Not Appreciable

SUMMARY — Values of the breaking load in pounds for type L hard copper tube soldered joint assemblies are reported here by Mr. Tracy, assistant metallurgist, The American Brass Co. Five different solders were tested, using untreated tap water and tap water acidified with carbon dioxide. The tests confirm practical experience that copper tubes assembled with soldered fittings give excellent service for conducting domestic water supplies and for hot water heating lines. Further, they show that corrosion of soldered joints is not appreciable even in water of pH6 after six years of continuous test. . . . Copper tubes and wrought copper or cast brass fittings are available only on allocation from the War Production Board. However, with the unlimited possibilities for the growth of this type of piping installation after the war is over, this scientific study of the limited effects of corrosion on soldered joints should be valuable material for heating, piping, or air conditioning engineers and contractors

WITH THE wide use of soldered joints in copper tubing systems, it became important to know whether any of the solders that might be employed would be corroded by water, leading to weakness and eventual failure at joints. The most logical way to obtain the information was to make soldered joint assemblies, run water through the joined pipes for long periods of time and determine the effect of corrosion on the solder by pulling the assemblies apart in a tensile testing machine; and such a procedure was followed.

The solders tested were:

Pure tin.
50 per cent lead—50 per cent tin.
60 per cent lead—39 per cent tin—1 per cent antimony.
95 per cent tin—5 per cent antimony.
95 per cent lead—5 per cent tin.

The freezing ranges of these solders are as follows: Pure tin, 450 F; 50-50 lead-tin, 421-361 F; 60-39-1 lead-tin-antimony, 446-367 F; 95-5 tin-antimony, 455-451 F; 95-5 lead-tin, 592-576 F. These values (except for 95-5 tin-antimony) are from the appendix to ASTM specification B32-40T [ASTM Standards, 1940 Supplement, Part *I*, p. 445]. The value for 95-5 tin-antimony is from Tin Solders, by S. J. Nightingale [British Non-Ferrous Metals Research Association, p. 78].

Test units were made up by soldering 9 in. lengths of nominal ½ in., type L, hard drawn copper tube into each end of a coupling. Both cast brass and wrought copper couplings were used. The brass couplings had the nominal composition of 85 per cent copper, 5 per cent zinc, 5 per cent tin and 5 per cent lead.

The tubes were cut to length with square ends and all burrs removed. The outside of the tube near the end was scoured with steel wool to remove tarnish and dirt and smeared with a thin film of soldering paste. The inside of the coupling was treated similarly. The assembly was put together, and heat applied to the fitting with an acetylene torch until the fitting and tube were hot enough to melt the solder. Approximately a ½ in. length of ⅛ in. diameter solder was melted into each joint. Assemblies with the two

Table 1—Breaking Loads in Pounds on ½ In. Type L Hard Copper Tube Solder Assemblies Tested One, Three, and Six Years in Hot Water at 140 F

100% Tin Solder	Breaking Loads in Pounds		
Wrought Copper Coupling	One Year	Three Years	Six Years
Uncorroded	3360 C	....	3710 C
Tap Water	2940 C	3300 C	2850 C
Tap Water + Carbon Dioxide	3190 C	3220 C	3120 C
Cast Brass Coupling			
Uncorroded	4120 T	....	4440 PO
Tap Water	3820 C	4040 PO (5%)*	3960 PO
Tap Water + Carbon Dioxide	4080 T	4170 PO (5%)*	3860 PO
50% Lead—50% Tin Solder			
Wrought Copper Coupling			
Uncorroded	3630 C	....	3060 C
Tap Water	3760 C	3190 C	3180 C
Tap Water + Carbon Dioxide	3530 C	3080 C	2920 C
Cast Brass Coupling			
Uncorroded	4600 PO (1%)*	....	4520 PO
Tap Water	4480 C	4450 PO (25%)*	4370 C
Tap Water + Carbon Dioxide	4460 PO (1%)*	4250 T	3990 PO
95% Tin—5% Antimony Solder			
Wrought Copper Coupling			
Uncorroded	3180 C	....	4070 C
Tap Water	3380 C	2990 C	2960 C
Tap Water + Carbon Dioxide	3120 C	3230 C	2870 C
Cast Brass Coupling			
Uncorroded	4690 C	....	4520 T
Tap Water	4370 PO (20%)*	4370 C	4310 T
Tap Water + Carbon Dioxide	4360 T	4210 T	4120 T
60% Lead—39% Tin—1% Antimony Solder			
Wrought Copper Coupling			
Uncorroded	3390 C	....	3020 C
Tap Water	3090 C	2990 C	3000 C
Tap Water + Carbon Dioxide	3610 C	3070 C	3100 C
Cast Brass Coupling			
Uncorroded	4720 C	....	4180 T
Tap Water	4510 PO (3%)*	4560 PO (3%)*	3960 T
Tap Water + Carbon Dioxide	4450 PO (4%)*	4390 T	3950 C
95% Lead—5% Tin Solder			
Wrought Copper Coupling			
Uncorroded	2440 C	....	2550 C
Tap Water	2430 C	2082 PO (50%)*	1950 PO (25%)*
Tap Water + Carbon Dioxide	2480 C	2090 PO (60%)*	1370 PO (50%)*
Cast Brass Coupling			
Uncorroded	3720 PO (3%)*	....	3430 PO (20%)*
Tap Water	3550 PO (20%)*	3240 PO (30%)*	3510 PO (15%)*
Tap Water + Carbon Dioxide	3970 PO (30%)*	3670 PO (20%)*	2910 PO (30%)*

C = break in middle of coupling.
T = break in tube near coupling.
PO = tube pulled out of coupling.
*The per cent figures in the body of the table refer to areas in soldered joints that are free from solder.

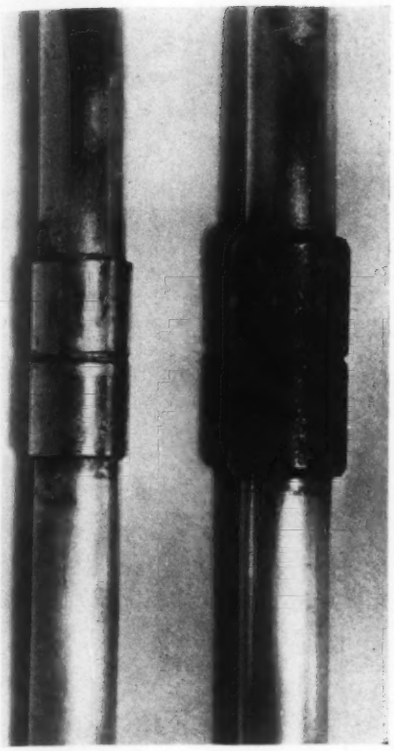


Fig. 1—Soldered joints. At left, copper tube with cast brass coupling. At right, copper tube with wrought copper coupling

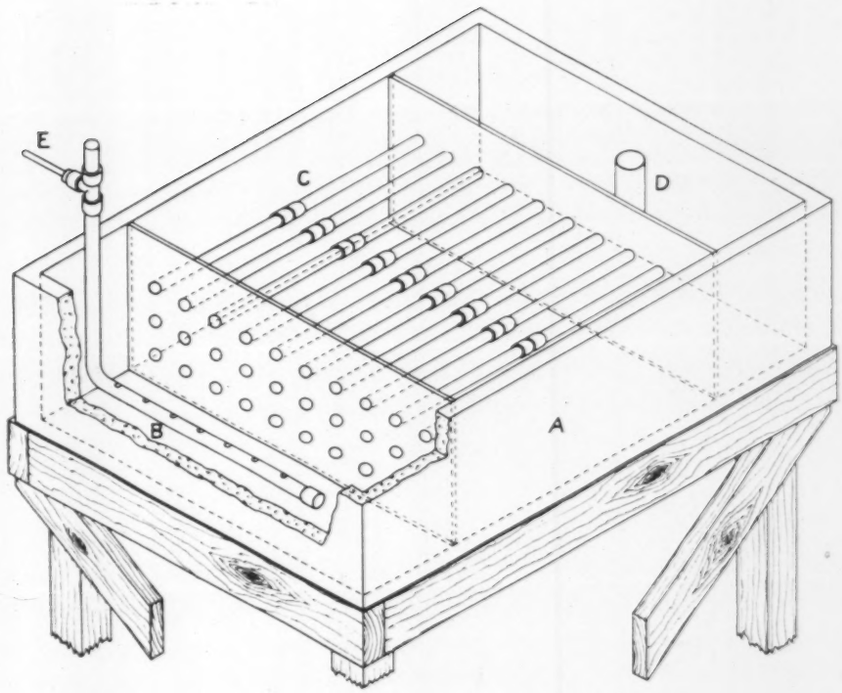


Fig. 2—The setup for testing the soldered joint assemblies. *A*, stoneware tank. *B*, water distributing pipe. *C*, test assemblies. *D*, water overflow pipe. *E*, connection to carbon dioxide tank

types of couplings are shown in Fig. 1.

The assemblies just described were soldered into two brass tube plates 18 in. apart fitted into a stoneware tank as shown in Fig. 2. The five types of solder in the two types of couplings were tested in triplicate, so 30 test assemblies were in the tank. Tap water at 140 F was run through the tubes continuously during the test. Another similar tank was fitted with tube assemblies, and tap water acidified with carbon dioxide to make it more corrosive was circulated through these tubes.

The average acidity of the untreated tap water was pH7, and of the tap water treated with carbon dioxide gas bubbles pH6, with some measurements showing pH5.4.

The results of tensile tests on uncorroded tube assemblies before they had been exposed to water, also similar assemblies exposed to plain tap water as well as water acidified with carbon dioxide, for periods of one, three and six years, are given in Table 1 as breaking load in pounds. The type of break in the tensile test is designated in the table as:

C—Coupling fractured at center (*B* and *C* in Fig. 3).

T—Tube fractured near coupling (*A* in Fig. 3).

PO—Tube pulled out of coupling (*D* and *E* in Fig. 3).

There is no evidence from the tensile tests or from the examination of corroded assemblies that corrosion had penetrated into the solder in any of the joints, although it was noted that the small ridges of excess solder at the ends of tubes inside the couplings were black and could be easily crumbled.

With the exception of assemblies soldered with the 95-5 lead-tin solder, all corroded assemblies having wrought copper couplings broke at the groove in the coupling at loads ranging from 2850 to 3180 pounds for the six year test, showing that the solder joint was stronger than the coupling, even after six years of exposure to corrosive hot water. Assemblies with cast brass couplings soldered with either 95-5 tin-antimony or 60-39-1 lead-tin-antimony, 100 per cent tin or 50-50 lead-tin solders broke in the tube near the coupling, in the coupling itself, or in a few cases the tube pulled out of the coupling at loads ranging from 3530 to 4310 pounds for the six year test. However, in those cases where the tube did pull out, the force necessary was almost equal to that required to break the tube or coupling.

Most of the assemblies made with 95-5 lead-tin solder pulled apart in the soldered joint when tested on the tensile machine and these joints had areas ranging from 3 per cent to 60 per cent of the total joint area free from solder. None of these joints, however, leaked during the test. It will be noted that with the 95-5 lead-tin solder the wrought copper couplings that broke had breaking strengths much lower than the same type of couplings with the other solders. This lower strength is probably due to annealing at the high temperature required to melt the 95-5 lead-tin solder.

The strongest joints were those made with the 95-5 tin-antimony and the 60-39-1 lead-tin-antimony solders. Joints made with 100 per cent tin and 50-50 tin-lead solders were almost as strong. Joints made with 95-5 lead-tin solder were considerably weaker than those made with the other solders but the technique employed may not have been the best for obtaining optimum results. [For installations where operating temperatures are likely to exceed 250 F, see report BMS83,

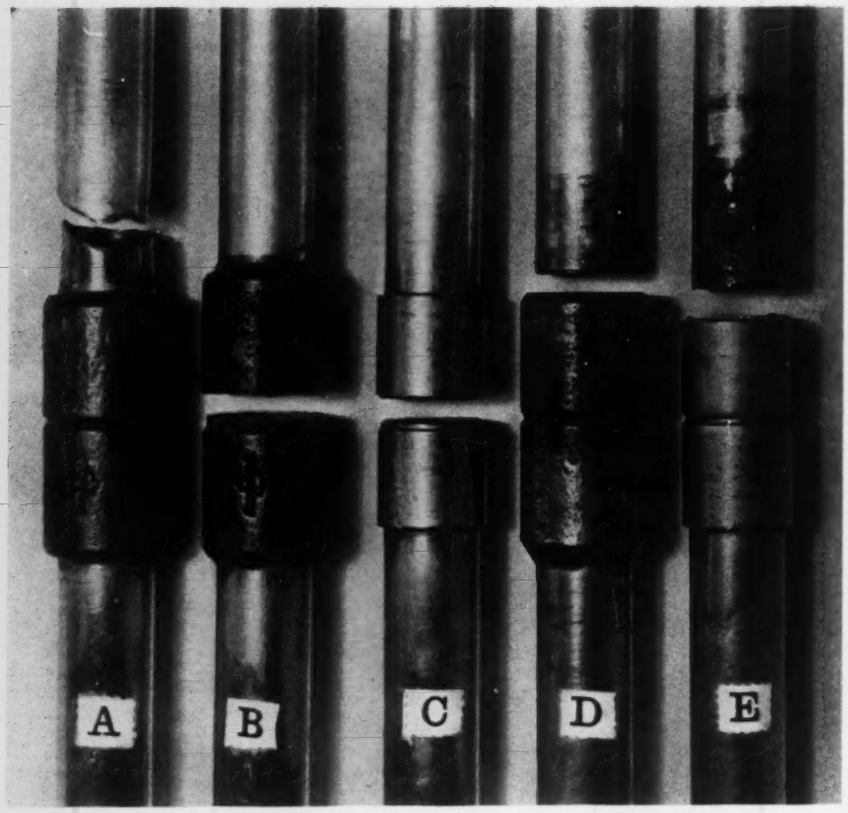


Fig. 3—Soldered joint assemblies, tensile tested. *A*, fracture in tube. *B* and *C*, fractures in couplings. *D* and *E*, tubes pulled out of couplings

Strength of Sleeve Joints in Copper Tubing Made With Various Lead-Base Solders, for sale by the Superintendent of Documents, Washington, D. C., for 10c].

The tests confirm practical experience that copper tubes assembled with soldered fittings will give excellent service for conducting domestic water supplies and for hot water heating lines. The tests show further that corrosion of soldered joints is not appreciable even in water of pH6 after six years of continuous test.

Strength of Joints in Copper Tubing

REPORT BMS83 of the National Bureau of Standards covers the strength of sleeve joints in copper tubing made with various lead base solders. It was prepared by Arthur R. Maupin and William H. Swanger and is for sale by the Superintendent of Documents, Washington, D. C., for 10c.

A previous investigation on soft soldered sleeve joints in copper tubing for plumbing lines and other uses dealt with joints made with two tin base solders. To supplement that investigation, the present one on similar joints made with various lead base solders was conducted. Solders of the following types were used: lead-silver, lead-tin-antimony, lead-cadmium, high lead-low tin, and high-purity lead. Tensile tests at room temperature (short time tests) were made, together with long time tests at temperatures ranging from 85 to 325 F. The information from the latter tests is much more useful than the results of short time tests in evaluating soldered joints for service. Consideration must always be given also to possible bond deterioration of the soldered joint at elevated temperatures.

On the basis of the results of the first investigation, joints in copper made with tin-base solders were considered satisfactory for general use, provided the temperature did not exceed 250 F. The results of the present study have shown that similar joints made with lead-base tin-free solders can be used with safety at temperatures as high as 325 F, the authors state.

STEAM FLOW THROUGH SAFETY VALVES

Bulletin No. 110, a 112 p. publication of the Engineering Experiment Station, Ohio State University, Columbus, Ohio, is entitled Steam Flow Through Safety Valves, by Eugene K. Falls. It represents a contribution from the Ohio State department of mechanical engineering with cooperation from the National Board of Boiler and Pressure Vessel Inspectors and from certain manufacturers of safety valves. Its price is $1.00.

According to a foreword by Paul Bucher, professor of mechanical engineering, the tests reported in this bulletin have led to certain helpful suggestions for increasing the accuracy of establishing rated relieving capacities of safety valves designed primarily for power boilers. This scientific approach should be applied to other safety valve problems, notably on equipment for low pressure installations, including both steam and hot water, he states.

CORROSION OF ALLOY STEEL BY HIGH TEMPERATURE STEAM

A paper on the corrosion of stressed alloy steel bars by high temperature steam was presented at the semi-annual meeting of the American Society of Mechanical Engineers held in Cleveland recently. The authors were H. L. Solberg, A. A. Potter, G. A. Hawkins, and J. T. Agnew, all of Purdue University.

The paper described the construction of apparatus and the techniques for measuring the amount of corrosion on stressed specimens. The data presented in the paper showed the effect of stress upon the corrosion of carbon-moly, 1.25 cr-moly, 2 cr-moly, 7 cr-moly, 9 cr-moly, and 18-8 stainless steel samples. Within the range of the test conditions stress does not influence the penetration or corrosion due to high temperature steam. No intergranular attack took place except for a small amount in the case of carbon-moly steel during a 2000 hr test. Chromium content increases the resistance of steels to corrosion by high temperature steam.

New Information About FLOW OF FLUIDS in the Critical Region

ALTHOUGH REYNOLDS performed his classic experiments on the flow of fluids in the eighties, it is only in recent years that his three classifications of flow—streamline, critical, and turbulent—have come into widespread use in engineering computations. His great contribution was the discovery that the type of flow depended only upon the dimensionless modulus which is today called Reynolds number. For Reynolds numbers below approximately 1000, the flow is always definitely streamline; for Reynolds numbers above approximately 5000, the flow is always turbulent. Between Reynolds numbers of 1000 and 5000, the flow is called critical inasmuch as it changes from streamline to turbulent, or *vice versa*.

There has always been some uncertainty as to the exact location of the critical region in terms of Reynolds numbers. For example, if the flow was streamline and the velocity of flow was increased so that it changed to turbulent, the critical region would lie within a certain band of Reynolds numbers. On the other hand, if the same fluid was initially in turbulent flow and the velocity decreased so that the flow gradually changed to streamline, the critical band would lie in a slightly different range of Reynolds numbers. Recently, A. H. Nissan, of the University of Birmingham in England, has published in Nature (May 2, 1942, pp. 501-502) the results of some experiments which indicate that in the critical region from 1000 to 5000 the flow, instead of being an indeterminate type, shows three distinct and different phases: (a) the first of these in the region from 1000 up to 2200, Nissan calls the *precritical;* (b) from 2200 to 2500, approximately, is the *true critical* flow region; and (c) in the range of Reynolds numbers from 2500 to 5000, he terms the flow *post critical*.

In the *precritical* region from 1000 to 2200, the head loss with increasing velocity increases at a slightly greater rate than in streamline flow for Reynolds numbers of less than 1000. In the *true critical* region from 2200 to 2500, the change in head is very great with an almost negligibly small increase in flow. In this region, the increase in head with increase in velocity would be an almost vertical line on a graph on which head was the ordinate. The critical region on such a plot is unmistakable. In the *post critical* region, from 2500 to approximately 5000, the head increases linearly with the velocity. The rate of increase in the post critical region is much greater than in the precritical region, but much less than in the critical region where the rate is almost infinite because of the vertical line of head versus velocity.

This discovery of Nissan's may, after further investigation, eventually result in a greater understanding of flow in the range of Reynolds numbers from 1000 to 5000. The flow in this range has exhibited many erratic and hitherto unexplainable phenomena.

"MAN IS AN AIR-ANIMAL"

"As A crab moves on the ocean-bottom, but is of the water, so man rests his feet upon the earth—but lives in the air. Man thinks of the crab as a water-animal; illogically and curiously, he calls himself a creature of the land.

"As water environs the crab, so air surrounds, permeates, and vivifies the body of man. If traces of noxious gas mingle with it, he coughs and his complexion turns deathly gray. If it becomes overcharged with water-droplets, he gropes helplessly in fog. If it moves too fast, he becomes a pitiable wind-swept creature, cowering in cellars and ditches. Even for rain he is dependent on air. If actually removed from air, he dies immediately.

"Physicists describe the air as tasteless, odorless, and invisible. It could not well be otherwise. But these are not so much its qualities as adjustments of man. For if the air impressed the senses, being at the same time all-pervasive, it would necessarily obscure all other tastes, odors, and sights.

"Air is so bound up with man's life that only with difficulty can he realize its existence as something in itself. To a savage it is as much an abstraction as consciousness; a child can conceive wind, which is air in motion, but not air itself. In our own language, *wind, mist* and *rain* are ancient words, but *air* is a late and learned borrowing of a Greek word, which itself originally meant *wind*.

"In his pre-natal months, indeed, man is aquatic. But thrust forth into the atmosphere—small and red—he sucks in a first breath spasmodically, and owns his allegiance to air. Seventy years later, a nurse stands by an old man's bed, waiting for what is known as 'the last breath.'

"Even among the so-called land-animals, man is less than most bound to the earth. His tree-dwelling ancestors may have descended to the ground furtively, as to a foreign and hostile region; in civilization people spend most of their time upon raised platforms called floors.

"As individual men move in a too well-known landscape without noticing its features, so man—fallaciously—takes for granted the all-pervasive air. His historians deal in lands and seas. But most movements of peoples have been not so much quests for better countries as for better atmospheric conditions. 'A place in the sun' explains much of history more exactly than we usually realize, except that just as often we should say, 'A place in the rain.' A thunderstorm in haytime may overthrow a ministry, and a slight average rise or fall of temperature may topple a throne; a shift in the storm-track can ruin an empire. In the twentieth century a temporary variation of rainfall put Okies upon the highway by the hundred-thousand, just as in the third century a similar shift might in a single year hurl the Huns against the Chinese frontier and set the blue-painted Caledonians swarming at Hadrian's Wall. In the mass as in the individual, man is less a land-animal than a creature of the air."—From Storm, by George R. Stewart, published by Random House.

[Editor's note—Concerned as they are with air and its characteristics, air conditioning engineers in particular will find Mr. Stewart's book fascinating reading.]

HOW CAN WE BURN BOTH COAL AND OIL?

WAR PROBLEMS FORUM

THE EDITOR—

My employers subscribe directly to your publication and as a result I have been a constant reader of it for the past five or six years. I have noted in recent months your different remarks regarding the need for conserving fuel oil in the east and, as I understand it, the difficulty is brought about by the transportation situation. In this vicinity everyone burns anthracite coal or fuel oil.

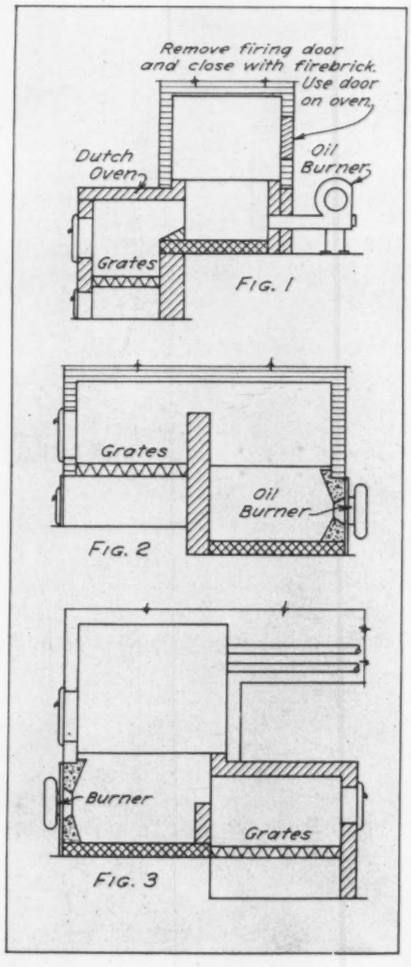
Believing that perhaps we will be able to get some fuel oil as well as some coal during the coming winter, I was wondering whether it would be possible to work out a plan whereby people with convertible oil burning equipment could not so install their oil burner as to leave the grates or most of them intact in order to be in a position to burn either coal or fuel oil or both at the same time.

Take for example, a coal burning boiler whose grates are still available but which had been converted to oil a few years ago. Do you know of any way in which the oil burner could be installed so that the grates would remain in place and oil or anthracite coal could be used either independently or together? If such a plan could be worked out it would greatly assist the eastern seaboard. —J. L. K.

REPLY (by KALMAN STEINER, member of HPAC's board of consulting & contributing editors)—In the larger boilers encountered in commercial and industrial heating plants, combinations for burning either coal or oil are more readily arranged than in domestic boilers or furnaces. In view of the uncertainties of fuel supply during wartime, it would be well for everyone to consider any feasible possibility of alternating fuels. If the supply of fuel oil threatens to be critical, even domestic installations can be rigged up so that in emergencies solid fuel may be burned.

A typical oil burner setting under a domestic round boiler is sketched in Fig. 1. In order to burn coal, it is possible to erect a dutch oven of firebrick and set the grates within it. If still available, the original ashpit door of the boiler may be used, as it is generally removed from the ashpit when the burner is installed. Also, the boiler firing door may be removed and attached to the oven. In that case, the firing opening of the boiler may be closed up with firebrick and a sheet metal or light steel facing bolted across. It will be necessary to excavate a pit at rear of boiler, as the oven must be somewhat lower than the boiler firepot in order to allow the coal combustion gases to enter. The most difficult feature will be the mounting of the grates on supports that will allow shaking down the ashes. This will have to be improvised of steel rods.

In rectangular cast iron or return tubular steel firebox boilers used in heating larger buildings, the problem is simpler. The oil burner firebox is built at the rear end and coal burning grates are set at the front in regular position. This is illustrated in Fig. 2.



The portable steel firebox boiler will also require a brick dutch oven, opposite from the oil burner. These boilers are sometimes oil fired from the rear; if so the dutch oven is built at the front, or vice versa, as illustrated in Fig. 3. The brickset firebox boiler could have a grate and enclosure erected to one side of the firebox, as the oil burner is universally placed at the front. Scotch marine boilers do not offer probability of combination firing of oil and solid fuel. In large industrial plants, of course, combination burners are available for handling any one or more of the three fuels—gas, oil, or pulverized coal.

When a dutch oven is constructed in any of the cases here indicated, several factors will have to be considered, aside from structural matters. The opening from the end of the grate into the boiler firebox will have to be at least as large as the total of the outlets from the firebox into the flues, and preferably should be 20 per cent greater. There will have to be a bridge wall that will deflect the burning coal gases upward and away from the oil burner nozzle. The draft will have to be set each time a change is made from one fuel to the other.

It is not likely that there will be necessity for burning the two fuels simultaneously, nor is it desirable. For one thing, the combustion safety control of the oil burner would be rendered inoperative by the heat of the coal fire and the burner relay would probably lock out the burner. For another, the draft requirement for the grate is higher than for the burner, so inefficient combustion of oil would result if the draft were set for coal, and smoky burning of the

coal would ensue were the draft set for oil.

The suggested dutch oven with grates can be employed only when the burner is of a design that throws a flame into the firebox horizontally. In the case of certain domestic types that use a flat hearth or vaporizing ring, then of course no such procedure is possible.

REPLY (by G. K. SAURWEIN)—The setting of the oil fired boiler at the New England deposit library is arranged so that coal may be burned on grates at the front end. This is a fire tube boiler with water legs around the firebox. It is set up about 2 ft higher on a brick setting, and the oil burner inserted at the rear. The grates at the front end were left out. The furnace is lined with fire brick in the usual way, with a bridge wall at the end of the grate location.

To change to coal firing it is simply necessary to lay in the grates, swing out the oil burner and plug the burner hole with refractory.

WPB ALLOCATES MATERIALS TO CONVERT TO COAL

IRON AND steel necessary to facilitate the conversion of oil burning installations to coal was allocated last month by the War Production Board to assure manufacture of grates and equipment for installation before winter. This action helps clear the way for conversion. All a plant operator or home owner need do is to place his order for the necessary equipment with his local heating contractor or dealer. No papers are required.

The requirements committee of WPB has set aside 11,009 tons of iron and steel for grate manufacturers during the third and fourth quarters of 1942. This includes 7546 tons of gray iron, 2978 tons of steel and 485 tons of other material. Manufacture of grates and other equipment can begin immediately upon delivery of the raw materials to the foundries. Preference rating of AA-3, top civilian goods rating, has been assigned to the delivery of such materials.

In order to get iron and steel for grates a manufacturer should file form PD-25F, if he is operating under PRP, or form PD-1A if he is not. Ratings authorized by the requirements committee will be assigned to these application forms by the plumbing and heating branch.

Plant operators and home owners in 19 seaboard states and the District of Columbia were advised that conservation order L-41 is not a barrier to construction necessary to convert from oil burners. Order L-41 put rigid restriction on all non-essential construction. In a supplementary order—L-41-b—the WPB expressly ruled that such restriction does not apply to conversion installations begun before January 1, 1943, in the following states: Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, Washington, West Virginia and the District of Columbia.

How Air Conditioning Aids the War Effort

AIR CONDITIONING is aiding the war effort in many, many ways. Here are a few brief paragraphs mentioning some examples of air conditioning applications for war, furnished by Margaret Ingels, Engineering Editor, Carrier Corp.:

TESTS UNDER TEMPERAMENTAL TEMPERATURES — Engineers operating a new cold room for testing radio parts really have to be quick change artists. No sooner does the thermometer go soaring up to tropical jungle levels of 150 F or hotter, than it turns tail and goes skidding down to 40 below zero or thereabouts.

These temperamental temperatures are created to check the performance of precision radio parts under extreme conditions. Such equipment includes sound detection instruments for the Navy, delicate detectors for anti-aircraft use, and similar apparatus which must stand up under the diverse climates of various parts of the globe.

Solution to the problem is a cold room, which is an 8 by 12 ft room lined with 8 in. of cork insulation in walls and floors, 10 in. in the ceiling. The equipment used to produce the low temperatures consists of a 50 hp refrigerating compressor with a diffuser installed in the center roof panel of the room.

A boiler and humidifier to produce the high humidity needed to simulate Caribbean conditions are likewise used, with a battery of electric strip heaters to produce temperatures above 150 F in a few moment's time.

TRACER BULLETS—The production of tracer bullets—which clearly define their paths through the atmosphere with a streak of light—at a recently completed ordnance plant has now been stepped up to maximum output with the use of more than two score dryers. The installation consists of units of both the 40 tray and 80 tray types, situated one to a room in the main drying building. Materials for the tracer and other use move into the drying rooms via conveyor belts and specially constructed carts for small individual loads, from a central depot near each of the drying buildings. The dryers are held at proper temperatures, with 100 per cent outside air used to dry the chemicals to an extremely low point. Tray drying time has been considerably cut over originally specified methods in use at some other ordnance plants.

MEAT SHRINKAGE—Pigs are known to be shy but when they shrink in public even in the form of bacon or hams, that's a different matter.

This "retiring instinct" on the part of some pork parts has been overcome, however, by Armour & Co., as a result of installing eight new smokehouses at the Heart of America plant of the Armour chain.

Controlled temperatures and humidity have put a stop to excess shrinkage and other losses in ham and bacon. As a result, the "processed porker" can be counted upon to yield a standard amount of various cuts.

Among the more important results of the installation has been the better production of sausages in five sausage smokehouses. One of these is refrigerated to low temperatures for more even coloring and temperature of thuringer, salami and other highly spiced cold sausages.

OFFICES—An unusual central air conditioning system which provides for efficient work on the four center floors of an office building was recently installed for an oil company. When several of the offices were consolidated in the building—which became supervisory and clerical headquarters in respect to production of aviation high octane gasoline and operations of midwest refineries—it was apparent that maximum performance of the more than 1000 employees, in respect to efficiency and accuracy, depended to considerable extent on an adequate air conditioning system.

The system, which operates at maximum economy and efficiency without taking up much space in the four floors, is a central system of 150 ton cooling capacity operating on a zoned basis. Rather than sacrificing an office or similar space in the building, arrangements were made to place the refrigerating plant in a band room or hall on the second floor, used for meetings in the past but now given over chiefly to storage. In this space are three refrigeration compressors, each on a floating base, to operate in conjunction with steam coils for year 'round conditioning. The plenum chamber, an outdoor air intake with manual or automatic control as desired, steam coils, and evaporative condenser were all placed in a compact space over the compressors and fan housing in this little used room, and can be removed to another location if necessary, with a minimum amount of time and trouble.

Cooled or warmed air from the refrigerating-heating plant is carried to the four floors of the oil company office through four main ducts, two to the east and two to the west side of the building. By dividing each floor into four zones, with compensation of the amount of cooled air according to the work carried on, it is possible to expediently cool areas side by side at minimum cost.

On the bookkeeping floors a larger quantity of cooled air is required than on the executive office floors, while the billing rooms where the many office machines develop considerable heat are supplied the maximum amount of cooling.

The blower provides a total of 45,000 cfm for the four floors. There is one thermostat per duct, four thermostats thus controlling the entire system, from floor to floor over a zone extending through all four floors.

PRECISE WEATHER
needed for
PRECISION WORK

Underground Laboratory for Manufacture of Precision Measuring Instruments Needed in War Production Has Air Conditioning System Which Maintains 69 F and 40 Per Cent Relative Humidity . . . . . By W. S. Bodinus

SUMMARY—One of the most important wartime applications of air conditioning is in gage manufacturing. Universal and accurate standards of measurement are the secret of mass production, allow subcontracting of the numerous parts of engines, planes, guns, tanks, etc., and make it possible for parts from New York to fit assemblies in California. . . . . Controlled temperatures and humidities — together with draftless, clean air—are essential to gage manufacture and comparison. Mr. Bodinus, of the Carrier Corp., describes here the air conditioning of one of these gage laboratories

A MIDDLE-WEST company—long engaged in making precision items used in the manufacture of machines, tools, jigs, and fixtures—has been called upon to extend its activities to produce measuring instruments needed in war production and formerly imported from abroad. These instruments must measure to within extreme accuracies, approaching the absolute. In order to do this, it is necessary that all work be carried out under standard conditions of temperature and humidity; because of these requirements, this company has constructed an underground laboratory away from the general turmoil of manufacturing, traffic and weather. In this special air conditioned space, scientists deftly carve the necessary flats, prisms, and lenses for the measurement of absolute sizes. The measurement of absolute sizes employs the principle known as "interferometry," which makes use of the various colors of light waves that white light is composed of; sizes can be expressed as accurate to within a few billionth parts of an inch.

Length standards similar to gage blocks, as well as thread plug, plain, and ring gages, are also finished in this room. One section is entirely devoted to the manufacture of optical flats, used in comparing gages against any gage block whose size is definitely known.

The checking of sizes by optical methods is not a new principle but has been rather neglected. The comparing is accomplished by setting up the gage to be checked and the length standard side by side, covering both with an optical flat. A monochromatic ray of light passes through the optical flat, reflecting itself from the upper surface of the gage block and from the lower surface of the optical flat. When these two reflected rays meet at half phases, they destroy one another.

causing darkness; where they meet at even phases, they reinforce themselves, creating greater brightness. Thus the setup as viewed will show alternate bands of dark and light streaks. By correct interpretation, it can positively be said just by visual observation that the object to be compared is so and so many millionths smaller or larger than the gage block against which comparison is made.

As the process involved in making and testing the gages must be carried on without delays caused by external effects, the laboratory is designed architecturally and mechanically to isolate it from external influences. The extreme accuracies required of the finished product necessitated special construction. Alfred S. Alschuler and R. N. Friedman were the architects.

Air Conditioning

The air conditioning equipment is of the spray type and supplies approximately 4000 cfm of air to the laboratory space. The system includes filters, a recirculating spray pump, spray nozzles, cooling coils, and heating and tempering coils. The cooling coil of the air conditioning unit is a part of the "Freon 12" refrigerating system, with the compressor of the balanced type with variable capacity. Equipped with special control apparatus to maintain a constant dew point, the refrigerating system provides the necessary cooling and dehumidification of the air in summer. Heating and humidification for winter are provided with the same air conditioning unit, which has heating coils and a spray type humidifier.

The distribution of the conditioned air is obtained by an intricate system of duct work with a number of diffusion outlets, each outlet supplying a small quantity of air. In this manner, even temperature is maintained throughout the entire laboratory. The return and exhaust duct work are in tunnels.

Although the laboratory is entirely underground, there are many of the same problems involved that are found in more conventional types of buildings. The variations in outdoor weather have lessened effect in the underground laboratory but are not entirely eliminated. A large portion of outdoor air is necessary for ventilation and this puts the same type of duty on the air conditioning system that is experienced in an above-ground structure when large quantities of outdoor air are circulated.

69 F—40%

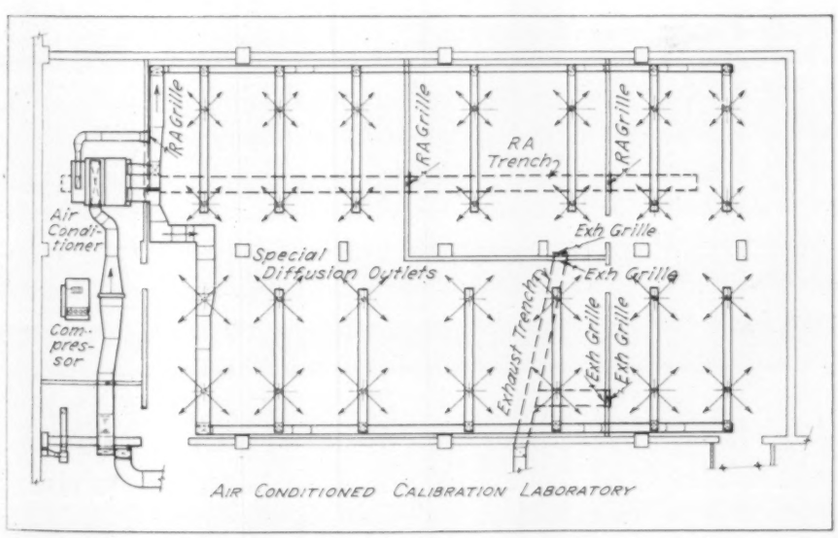
The temperature of the air in the laboratory is maintained at 69 F. Any variation in temperature will cause minute expansion and contraction in the cutting and grinding gears, or a slight variation in the surfaces of the optical flats. A minute variation caused by temperature change is multiplied by the sensitivity ratio of the instrument and is magnified considerably.

Relative humidity is maintained the year around at 40 per cent. At this level the hygroscopic portions of the gages and equipment are kept free of surface moisture. This humidity is low enough to eliminate condensation on the glass plate and frame that might occur in an unconditioned or improperly designed air conditioned laboratory.

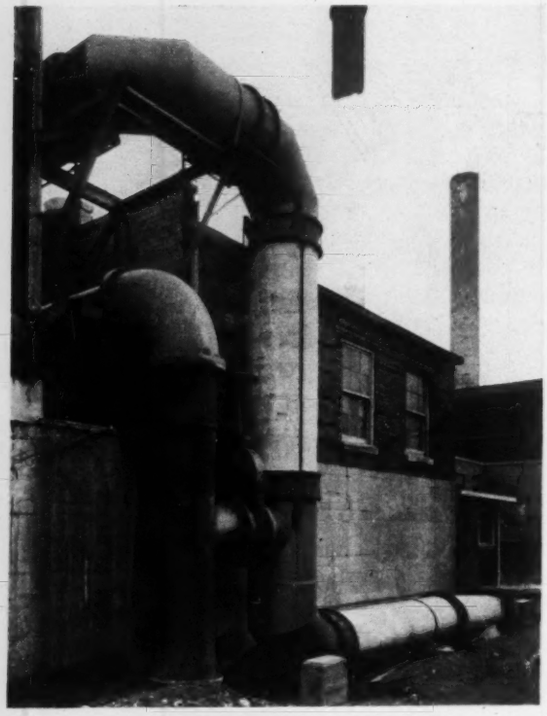
Air motion and air distribution were given special consideration. Designed air velocity in the work spaces is less than 5 fpm to avoid drafts and air stratification, which would cause unequal heat transfer from surfaces of the gages and result in variations of sizes and internal strain.

Air cleanliness is of the utmost importance. The smallest dust particle will make its presence known in "light rings." The conditioned air is thoroughly filtered and refiltered to eliminate the impurities and keep the air supply to the working space free of dust particles. The filtering equipment consists of an air washer with finely divided spray nozzles washing over a bank of cooling coils, through which the air passes. In addition, all of the air —including outside and recirculated—passes through conventional throw-away type filters.

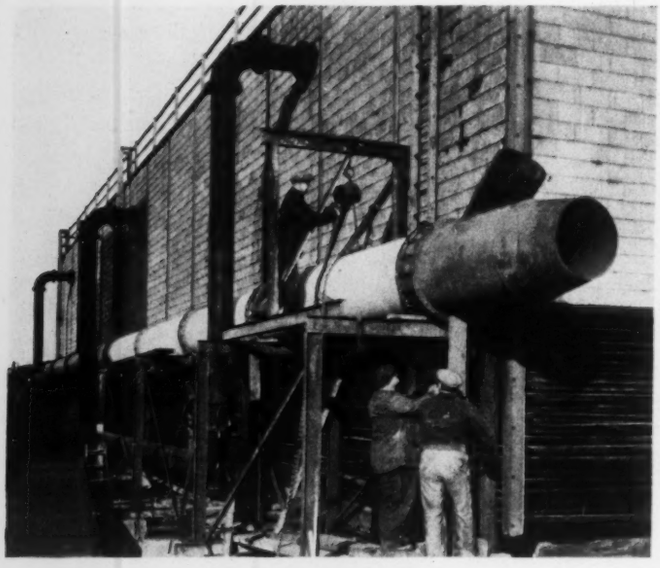
Recognizing the importance of cleanliness in the room, the laboratory is equipped with flush type ceiling fluorescent lighting, with flat surface fixtures and streamlined projections and molding to reduce the number of places where dust can collect. Further to assure cleanliness in the assembly and finishing rooms, the dust creating departments (grinding and polishing rooms) have been partitioned off. The conditioned air, however, is supplied to all the departments, as each operation requires constant air temperature.



AIR CONDITIONED CALIBRATION LABORATORY



WAR CONSTRUCTION ACTIVITIES OF HEATING AND PIPING CONTRACTORS RANGE FROM PIPING AN ORDNANCE WORKS TO MOVING ONE RADIATOR



TYPICAL OF the war project work being done by heating and piping contractors who are actively engaged in construction for victory are the jobs illustrated in these photos. One of the installations involved the use of some 37,000 ft of 42 in. diameter pipe, enameled inside and coated outside, for conveying water required in a munitions manufacturing process.

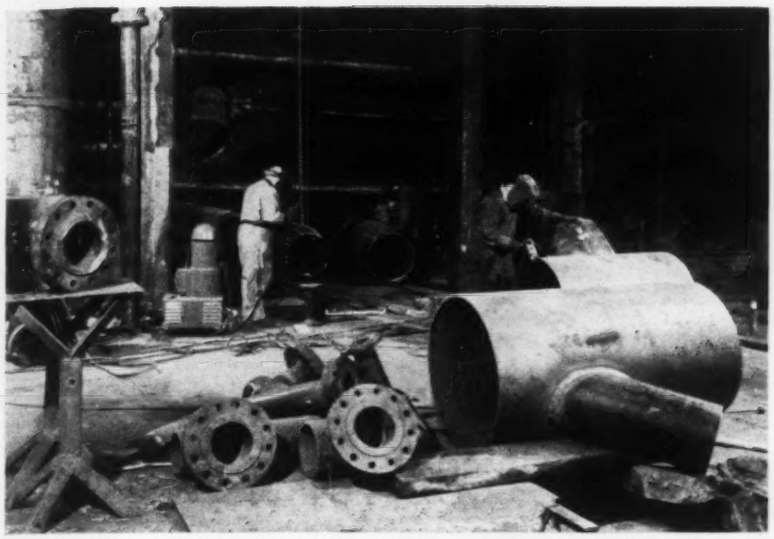
The other project shown is a power plant, where an extensive piping system for condenser cooling water was installed.

Due to difficulties in obtaining steel pipe, large quantities of asbestos-cement pipe were used, and the contractor had to work out methods of connecting the welded steel pipe and the asbestos-cement pipe. Welded steel fittings were also fabricated by the contractor, as cast iron fittings couldn't be had.

In addition to such large projects, contractors

are also handling revisions in industrial plant heating, piping and air conditioning systems, when new manufacturing processes make such changes necessary.

Howard W. Evans, president of Piping Contractors, Inc., who furnished these pictures, is no stranger to war work. Hanging in his office is a photograph taken outside a contractor shop during World War I, on the first gasless Sunday. It shows a collection of automobiles (which today would make excellent museum pieces) adapted to use kerosene instead of gasoline in order to cooperate with the government's voluntary gasoline rationing campaign of 25 years ago.



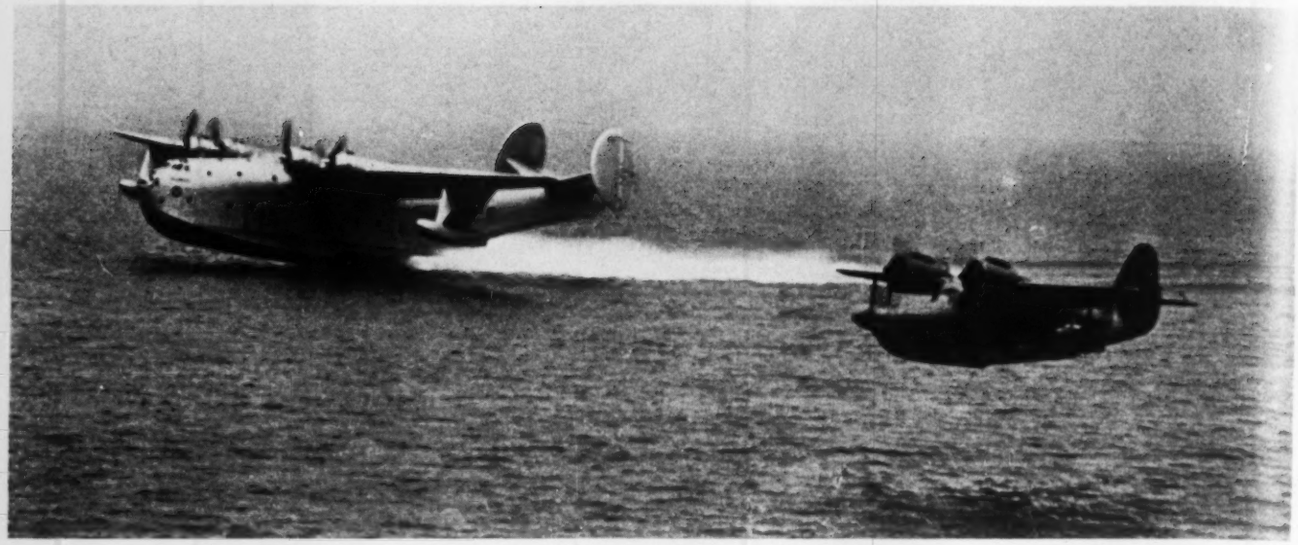
COMMERCIAL, INDUSTRIAL STOKER SALES UP

Factory sales of commercial and industrial size stokers increased in every classification for the first half of 1942 over the same period last year, according to statistics furnished by 56 manufacturers reporting in June, 1942, to the U. S. Department of Commerce, the Committee of Ten —Coal & Heating Industries points out. The increase is particularly noticeable in stokers having a capacity of over 300 lb per hr of coal feeding rate. For 1942 there were 2021 units sold for commercial and industrial use, contrasted with 1319 units for the January-June months of 1941. This increase of larger stoker sales reflects the war expansion in the industrial demand for steam, heat, and power.

Factory sales of mechanical coal stokers of all sizes and types for the first half of this year fell off 21½ per cent as compared with the corresponding period in 1941. Total factory sales for the first six months of 1942 were 52,816 units as against a total of 67,367 in the same period of last year. Class 1 stokers—residential heating units with a capacity up to 60 lb per hr of coal feed—accounted for all the decline in sales this year, due largely to the stopping of stoker sales activities on these sizes for several weeks last spring.

An analysis by the Committee of Ten of the permits for installation of fuel burning equipment issued by the Chicago smoke department for the first seven months of 1942, compared with the same period in 1941, indicates a downward trend in the sale of oil burning equipment. Permits for 104 oil burner installations were granted for these seven months this year, compared to 166 in the corresponding months of 1941. During this same period permits were granted for the installation of 726 underfeed stokers in 1942, compared to 647 in the January-July period of 1941. All told, the city issued permits for 882 fuel burning installations of all types and kinds in the seven months period of 1942, compared to 880 in the comparable months of 1941.

City permits for the installation of fuel burning equipment are not required for residences and apartment buildings of less than three flats.



Giant Flying Boats May Solve United Nations Shipping Problem

THE ENTIRE flight deck and a large portion of the main deck of the Martin Mars, world's largest flying boat, is supercharged, permitting normal breathing without oxygen masks or tubes miles above the clouds, it has been revealed by the Glenn L. Martin Co. In addition, the entire crew enjoys at all times the benefits of heating, however high into the frigid atmosphere above the earth the giant plane may range.

These twin features of supercharging and heating are not whims or frills. They contribute to the efficiency of all hands by permitting them to work, fight, eat, and sleep with the same comfort they would have on a surface vessel or on land. Glenn L. Martin, pioneer champion of long range air transport for both war and peace time, contends that physical comfort plays an important part in the efficiency of all hands aboard, especially at high altitudes. In giving $450,000 to found the Minta Martin aeronautical laboratory recently, Mr. Martin pointed out that the effect on pilots of high altitude flying is one of the great problems requiring intensive study. "I hope that from the new laboratory," he said, "will come developments which will make substratosphere flying more comfortable and safer for our combat pilots. It is also important that after the war passengers be flown at higher altitudes."

The supercharging of the mighty ship is confined, for practical reasons, to that portion forward of the wings. It is done with an auxiliary engine that keeps the forepart of the ship pumped full of air. Even though the air about the ship may be too thin to support life, the men flying her don't have to sit about, movie fashion, with oxygen tubes in their mouths. They just forget the whole thing and breathe naturally as they go about their business of operating the ship, laying her course, and sending and receiving messages.

From the flight deck, where all this goes on, a spiral staircase descends to the main deck, where all hands have their quarters. These include staterooms, washrooms, two large dining rooms, and a galley. The galley's equipment includes a three burner electric stove and an electric refrigerator.

The engine pumping in air begins to operate at 8000 ft, where ordinary breathing is still easy. Although it was not feasible to supercharge the whole vessel, the entire interior is heated. The air drawn in passes over hot coils, which warm it to comfortable temperature. The process is necessitated by the fact that the air high above the earth, even in the tropics, is frigid.

Because of differences in air pressure within the hull when the ship is at high altitude, it is necessary for a man moving from one end of the ship to the other to pass through a decompression chamber. This allows him to become accustomed gradually to the different atmosphere into which he is about to step. Oxygen stations are set up throughout the hull, which has the volume of a 15 room house, in case of emergency.

Another interesting feature of the Mars is the 28 station telephone system that covers all points of the hull. A man can sit at his meal high above the clouds and receive or give orders between mouthfuls.

In these ways, without sacrificing a bit of her efficiency in peace or in battle, the Mars makes her crew of 13 men as comfortable above the clouds as they would be on a surface vessel or on land.

Above—The Glenn L. Martin Co.'s flying boat, the 70 ton Mars, takes off for her maiden flight, her size clearly shown in the contrast of a Grumman amphibian beside her. This ship, biggest flying boat in the world and herald of others twice and more her size, is being hailed as an answer to the shipping crisis, so vital to the prosecution of the war by the United Nations. Reasonable numbers of them are said by Glenn L. Martin to be able to move as much cargo as surface ships because of high speed and greater frequency of trips

"OPEN FOR DISCUSSION"
Communications to the Editor

WHY A CLOSE NIPPLE IN THE HARTFORD LOOP?

THE EDITOR—

In a delayed perusal of the May, 1942, HPAC, I came across the reply of Samuel R. Lewis to a reader seeking information as to the reason for a close nipple in the Hartford loop.

In the interest of further clarification of this subject for the benefit of this reader as well as others who may not be fully enlightened on the point in question, I feel constrained to take friendly issue with Mr. Lewis as to the accuracy of his explanation.

Briefly, the reason for a close nipple in the horizontal connection of the Hartford loop is to prevent water hammer at that point. It is a generally understood fact that the cause of water hammer is the rapid condensation of steam when in counterflow with relatively cooler water of condensation in a horizontal pipe. The Hartford loop provides positive protection against lowering the boiler water line more than a limited amount as a result of pressure differences between the boiler and remote points of the system. The distance allowed is usually 2 in. in the case of small residential boilers. In the event that the water line is lowered this amount because of heavy steam demand, pressure difference or other reason, steam from the boiler passes into the horizontal connection of the loop over the returning condensate and water hammer results.

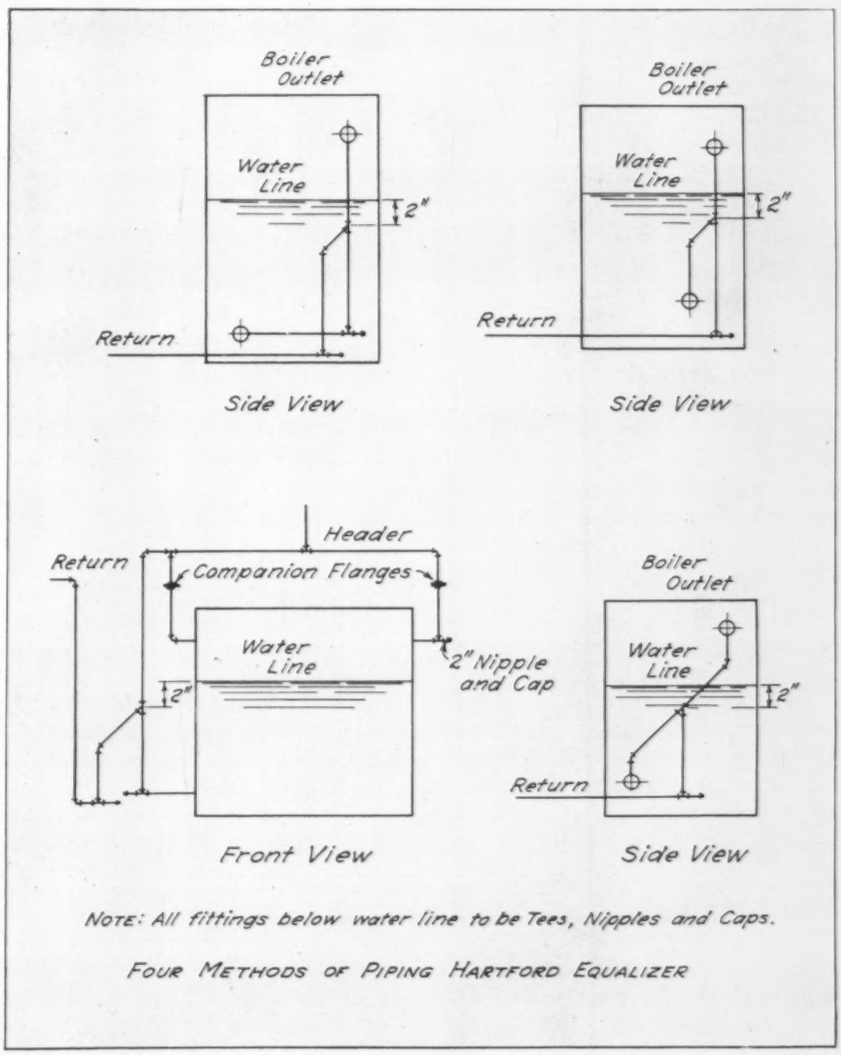
In order to prevent such an occurrence, of which we had a number of early objectionable instances, our specifications were revised so as to require a Y connection in the Hartford loop instead of the usual "close" nipple or "short" horizontal connection. This practice results in an absolutely clean "cut-off" in the event of low water line with no possibility of water hammer. The accompanying print shows four methods by which this type of connection can be easily incorporated in the piping assembly.

I fail to follow Mr. Lewis' idea that a large volume of water could be withheld from the boiler by reason of pressure difference in the case of a long horizontal connection. If the boiler water line were at its normal level, the horizontal connection would be full of water regardless of its length; on the other hand, if the horizontal connection contained steam only, the boiler water line would already have dropped to its predetermined minimum level and the Hartford loop would merely be performing the function for which it was intended. If the pressure difference increased sufficiently, the water in the return line would be blown back into the system in the process of pressure equalization between the boiler and the low pressure zone. In this case the water line of the boiler would not be further disturbed except to be restored to its normal level upon completion of the pressure equalization process.

I would be very much interested in any comments you may care to make in connection with this controversy.—R. D. MCNEICE, appliance engineer, gas department, Public Service Electric and Gas Co.

THE EDITOR—

Last May I attempted to explain why a short or close nipple always is specified to be placed in the side



NOTE: All fittings below water line to be Tees, Nipples and Caps.

FOUR METHODS OF PIPING HARTFORD EQUALIZER

outlet of the tee through which return water enters a boiler via a Hartford loop.

I have now to confess that I never have had any trouble with hundreds of these equalizing loops installed on boilers under my direction and so lack the authority in explanation only to be gained by experience with constructions which deviate from the normal.

Mr. McNeice very kindly has given me the benefit of his experience. He has found that unless the connection from the return main is made with a close nipple or equivalent, from a riser coming up from an assuredly wet return, water hammer will result whenever the water line in the boiler becomes low enough no longer to seal off the top of the horizontal connection.

It is beyond argument that when steam comes in contact with a considerable surface of relatively cool water in any horizontal pipe the conditions are favorable for water hammer.

Mr. McNeice has seen a number of cases in which, due to failure to install the shortest possible horizontal pipe connection into the side outlet of the tee in the equalizing loop, serious water hammer did occur.

As an aid to its customers, Mr. McNeice's company suggests going even further than to install the regulation close nipple into the tee, advocating, instead of a plain tee, a special tee called a 45 deg Y bend, in which the side outlet looks down at an angle of 45 deg and receives the upcoming return water. With this arrangement, when the center of the Y bend is 2 in. below the normal water level in the boiler, there has been no difficulty due to water hammer. I am happy to acknowledge Mr. McNeice's contribution and to endorse his reasoning and solution.

The 45 deg Y bend is shown as a standard fitting in the catalogs of most supply houses.—SAMUEL R. LEWIS, consulting mechanical engineer; member of HPAC's board of consulting & contributing editors.

THE FIGHT FOR THE CEILING

(Air Conditioning and Lighting)

THE EDITOR—

Considerable water has flown over the dam since first the question "Who owns the ceiling?" arose in our territory, and I'm very much in accord with Knight Porter's opening comment, in his article in the August HPAC, that "it's not really a 'fight' between the air conditioning, illuminating, and acoustical engineer" but rather only the need for an appreciation of the other fellow's problem and cooperation in the early design stage, that is needed to satisfactorily work out the joint problem.

Perhaps the worst headache that the air conditioning engineer has experienced the last couple of years has been the difficulty in getting the eventual lighting load established, particularly in the case where the question of whether to use incandescent or fluorescent lighting has, due to the larger initial cost of fluorescent as against its lower operating cost, resulted in the owner's indecision and later reversal of decision—with the net result that the air conditioning engineer has had to refigure his load two or even more times. Present day lighting loads on the last dozen jobs that I have designed or helped design have varied from as low as 15 per cent to over 70 per cent, with the average between 30 and 50 per cent of the total internal sensible load—which in turn determines the air quantity supplied, duct sizes, and other equipment sizing. Experience also indicates that with modern higher intensity (from 50 to 150 foot candles), lights are kept burning even though venetian blinds are adjusted to keep out direct sunlight, this being particularly true in the case of fluorescent lighting whose color blends better with daylight. All of the above is mentioned to indicate the importance to the air conditioning engineer of the lighting load and his need for the cooperation of the illuminating engineer. In turn, the illuminating engineers and lighting equipment representatives with whom I've had considerable contact tell me that mutual cooperation is of great help to them. Certainly no owner or architect is going to ignore the statement that an air conditioning engineer is practically forced to make at times, that his air conditioning system simply can't function satisfactorily without either changing the type of lighting fixture or its type of mounting.

We made a number of laboratory tests about a year ago using a ceiling outlet and several types of ceiling mounted fluorescent fixtures. One unshielded fixture which delivered the cold air stream over the lamp showed a reduction of over 20 per cent in light output with 50 F delivered air. However, in most fixtures the lamps are so shielded that light output is not materially affected.

However, we found very definitely that most lighting fixtures act as beams and divert the air stream downward. Ceiling outlets, and the application of many side wall grilles, are designed to take advantage of the fact that air tends to hold to the ceiling, and now suddenly we meet the problem resulting from a ceiling mounted fluorescent lighting fixture—in effect, a beam knocking this careful design into a cocked hat by definitely "dumping" the air steam downward. The worst lighting fixture in this respect, mounted tight against a 9 ft high ceiling, 3 ft from the edge of the air outlet, produced a very serious dumping action resulting in an air movement downward of over 200 fpm. Under the same condition a half oval type did not produce any noticeable movement at head level, as the air tended to follow around the oval surface. Most fixtures, however, did produce objectionable air movement. We found that moving the fixture to 6 ft from the edge of the air outlet still resulted in unsatisfactory conditions, even though measurements were taken 6 ft below the ceiling. Suspending the fluorescent fixtures only a few inches, 4 to 8 in., is usually sufficient with the more widely used type of ceiling outlets to avoid the "dumping" which produces drafts. Strange as it may seem at first thought, having the blank end of the fixture only a foot from the edge of the air outlet did not result in difficulties, the reason being the

small amount of air directed downward.

In passing it might be well to point out to air conditioning men that a 40 watt incandescent lamp means 40 × 3.4 Btu per hr of heat, while with a 40 watt fluorescent lamp about 25 per cent must be added for auxiliary loss, if the auxiliaries are in the fixture as is customary when using alternating current. If by any chance direct current is used, check carefully, as the per cent to be added for the auxiliaries is considerably greater than 25.

One point of Mr. Porter's article, which, in spite of his added modifications, all of which are correct, might give an inexperienced designer an erroneous rule of thumb, is, namely, that 12 air changes is a dividing line between a draftless and drafty condition. Personally, I've seen a larger percentage of drafty conditions exist in jobs having air change of less than eight per hour than in those having a higher air change—probably due to the fact that less care and thought was used, or possibly due to unwillingness to spend sufficient money to provide proper air distribution on apparently simple jobs.

Summarizing, one might say

1) Become reconciled to the fact that upwards of 50 foot candles of lighting will be used. Don't fight the lighting man—after all, his lighting often *makes* air conditioning jobs.

2) Providing light requires watts, *all* of which will be converted into heat—which must be removed. Be sure you get the full lighting load, including all auxiliary apparatus, in your Btu estimate or the owner will feel he got a fine lighting system and a bum air conditioning installation.

3) Help the owner (and incidentally the lighting man) by pointing out the "dumping" action of certain fixtures. Certainly both would rather avoid a headache and a later patched up job.

In closing may I say that I feel that today there is very good cooperation between the air conditioning engineers that have been doing the majority of the larger and better jobs in our territory and the illuminating engineers and lighting equipment representatives, and that the degree of cooperation improves as they become better acquainted with each other and each other's problems.

Knight Porter's article is a well written, interesting summary and should help the air conditioning engineer better to understand the lighting engineer's problems.—C. H. RANDOLPH, air conditioning engineer, Wisconsin Electric Power Co.

Readers of HEATING, PIPING & AIR CONDITIONING are invited to contribute their views to "Open for Discussion."

THE EDITOR—

Mr. Porter's article in the August HPAC very clearly points out the necessity for close coordination between lighting, air conditioning, and sound control. This is all part of advanced thinking in connection with environments in which human beings must live and work.

I was impressed by the calm way in which Mr. Porter approaches the relationship between light and heat—there has been altogether too much misunderstanding of this relationship. The threshold of sensation for radiant temperature has been established not only in careful laboratory researches but in practical field investigations. It is quite safe to say that for many years any general lighting that would be provided will not introduce a radiant heat problem. Strictly localized lighting, where the foot candles extend beyond the 100 mark, will produce radiant heat that will be perceptible, but to say that this radiant heat will in every instance be uncomfortable or unwelcome is to deny the evidence.

From the standpoint of sensible heat a kwhr produces 3413 Btu regardless of the light source that might be used. The higher luminous efficiency of the fluorescent lamp and the mercury lamp means that for a given connected load more foot candles can be provided for a given allowable heat gain on the air conditioning system, but from the standpoint of lighting and air conditioning practice this is of only transient interest because the advances in lighting are so rapid that the lighting industry will soon be knocking at the 5 to 7.5 watts per sq ft, stated by Mr. Porter to be critical from the standpoint of air motion.

It seems to me that with the establishment of these basic facts, each industry involved should devote its best efforts towards ways and means of allowing the consumer to utilize the best that each has to offer, without attempting to impose limitations on the use of any device because of commercial weakness, or a lack of technical skill.—HOWARD M. SHARP, manager, lighting bureau, Buffalo Niagara and Eastern Power Corp.

SALES ENGINEERING FIRMS IMPORTANT TO WAR EFFORT

THE EDITOR—

An editorial appeared recently in a metropolitan newspaper in which considerable satisfaction was expressed at the speed with which the House had drafted and passed a bill prohibiting the payment of commissions and contingent fees for the negotiation of war contracts. While everyone with a sense of decency must be indignant about the alleged practices of certain individuals and so-called organizations, it is possible for an improperly drafted bill to work great injury.

Many manufacturing concerns, large and small, are conducting their sales throughout the country through manufacturers' agents or sales engineering organizations. This arrangement has proved to be practical and economical. It would not be practical for the average size manufacturer of fans, for instance, to have a branch office in a city like Washington, Baltimore, or Cincinnati; on the other hand, it would not be possible for the manufacturer to cover these cities thoroughly and competently by a traveling engineer from the main office. A resident sales engineering firm is therefore the satisfactory and conventional solution. These sales engineers have a number of accounts and if they are industrious and the accounts are of quality, they make a good living, while this arrangement permits the manufacturer to determine his cost of sales to a nicety.

These resident sales engineers render a distinct service. They are

selected by the manufacturer because they are capable engineers and can give immediate and competent advice and cooperation on any engineering problem which concerns their product. Without the possibility of communicating by telephone with the resident sales engineer and having him call promptly for a discussion, the engineer in a government department desiring information would have to send the necessary data to the home office of the manufacturer. Usually these data are insufficient; long correspondence ensues, a great deal of time is wasted, and the possibility of errors is accentuated.

An improperly drafted bill would be a deterrent to the war effort, as the sales engineers who have done their work capably for many years for an entirely reasonable compensation would not be available for advice and assistance because the smaller manufacturer, even under present war conditions, would not be justified by the volume of business obtainable in maintaining an office in Washington. Such a bill would result in a bonus to the manufacturer with an office in Washington and a penalty to the smaller manufacturer. It would therefore limit competition and thereby increase the cost to the government. The manufacturers' agent would have to fold up.

Such a bill should be carefully drawn to abolish specifically the malpractices, but it should not be so worded that it would interfere with legitimate and long established business practices. — A. RUST-OPPENHEIM, president, Anemostat Corp. of America.

Selected Listing of Articles on Fuel Conservation Published in HEATING, PIPING & AIR CONDITIONING

THE FOLLOWING listing is presented for the convenience of readers who may wish to refer to their back issues of HPAC for data on fuel conservation:

Accurate Method for Control of Heating Fuel Costs, An, by W. S. Bard (August 1937, p. 473)

Alert Management, Meters, and Proper Control Cut Building Heating Costs, by Lester S. Ries (July 1934, p. 293)

Attention to Details Cuts Cost of Heating and Other Services, by C. W. Kimball (January 1940, p. 4)

Attention to Heating Plant Now Will Pay Dividends Next Winter, by Lewis W. Mauger (July 1939, p. 413)

Buying and Checking Fuel, by R. E. Hieronymus (January 1942, p. 11)

Buying and Checking Fuel, by R. E. Hieronymus (February 1942, p. 96)

Check Plant and Building Heating Now, by T. Napier Adlam (April 1935, p. 177)

Check Plant and Building Heating, by T. Napier Adlam (June 1935, p. 285)

Conservation for National Defense—Fuel Economy in Oil Fired Plants, by Kalman Steiner (August 1941, p. 481)

Daily Degree Day Check Saves Heating System, by R. E. Hieronymus (December 1940, p. 707)

Daily Degree Day Check Saves Heating System, by R. E. Hieronymus (January 1941, p. 9)

District Heating Companies Point Way to Steam Savings, by George A. Orrok, Jr. (July 1938, p. 459)

Eleven Ways Heating Has Been Improved, by Lewis W. Mauger (March 1940, p. 174)

Get Ready Now for Winter Operation of Conditioning System, by Rush D. Touton (October 1936, p. 550)

Heating Fuel Consumption Data, by Kalman Steiner (October 1937, p. 618)

Heating Plant Check-Up Pays!, by C. W. Kimball (October 1934, p. 426)

Heating System Control Methods and Reducing Fuel Consumption, by Kalman Steiner (March 1937, p. 170)

How a Pioneer Skyscraper Has Obtained Heat Economy, by Rex E. Hieronymus (March 1939, p. 149)

How Much Steam for Heating? (September 1940, p. 545)

How to Avoid Waste in Plant Heating, by Mortimer Freund (March 1938, p. 169)

How to Operate Oil-Fired Heating Plants Efficiently, by Paul R. Unger and Kalman Steiner (May 1936, p. 255)

How to Plan an Operating Schedule for Heating and Air Conditioning, by Charles N. Bailey (October 1939, p. 601)

How to Reduce Next Winter's Heating Costs, by J. Earl Seiter (August 1935, p. 378)

How to Save Heating Dollars, by H. P. Scott (April 1941, p. 239)

How We Improved the Heating of Our Plant, by H. A. Richardson (April 1940, p. 235)

Method of Reducing Fuel Consumption, A, by H. P. Scott (March 1941, p. 163)

Organized Maintenance Procedure Cuts Fuel Consumption for School Heating —an Interview with John Howatt (January 1939, p. 9)

Planning an Operating Schedule to Save Building Heating Steam, by Charles N. Bailey (June 1939, p. 373)

Regular Supervision of Apartment Hotel Heating Plants Cuts Costs, by Kalman Steiner (July 1939, p. 425)

Reliable Steam Consumption Records Mean Better Heating at Minimum Cost, by Lyman R. Flook (June 1936, p. 320)

Setting Up a Heat Economy Program, by Rex E. Hieronymus (January 1937, p. 25)

Simple Changes in Heating Systems and Better Operation Reduce Steam Costs, by George H. Tuttle (December 1935, p. 570)

Study of Building Heating Economies Shows Money Value of Good Operation, by Earle Shultz and J. C. Butler (October 1939, p. 609)

Study of Building Heating Economies Shows Money Value of Good Operation, by Earle Shultz and J. C. Butler (November 1939, p. 667)

Technical Problems in Analyzing Fuel Consumption, by W. S. Bard (September 1937, p. 541)

22% Less Steam Heats Office Building, by William S. Downs (March 1938, p. 177)

ENGINEMEN NEEDED IN FEDERAL BUILDINGS

Enginemen (steam-electric) are needed to be in charge of heating, refrigerating and ventilating systems in federal buildings in Washington, D. C. The United States Civil Service Commission is recruiting enginemen for positions paying from $1680 to $2040 a year.

Experience in the operation or installation of air conditioning equipment will be accepted as qualifying. Applicants for all positions must show experience with electrical machinery. Experience in the operation of diesel, air conditioning, or refrigerating equipment is desirable, but not essential.

There is no education requirement. There are no age limits. Filing application forms, obtainable at first and second class post offices, is all that is necessary to be considered.

Exhaust Office Air Heats Steel Storage Warehouse

Sheet Stocks Protected from Condensation Damage by Duct System Using Waste Heat

HEAT CONSERVATION through the double use of warmed air is practiced by Joseph T. Ryerson & Son, Inc., Chicago, as a war and peacetime economy. The arrangement has been in use for many years, and has saved thousands of dollars in operating and maintenance costs and in protection of steel products. Changes have been made from time to time as needed, and recently some of the duct work was revised because of a re-arrangement of storage space.

The two main floors of the office building, which adjoins the warehouse section, are served by a ventilating system which supplies heated, humidified, and filtered air in winter, and filtered outside air in summer. Cooling coils can be added at some future date if it is decided to make the necessary expenditure. The air is distributed to the office spaces by means of a 50,000 cfm fan. In the general office areas, some of the supply ducts were built around the circular columns for the sake of appearance; the air is discharged through grilles around the circumferences of the column tops. These "duct columns" look exactly like the others, except that they are of increased diameter.

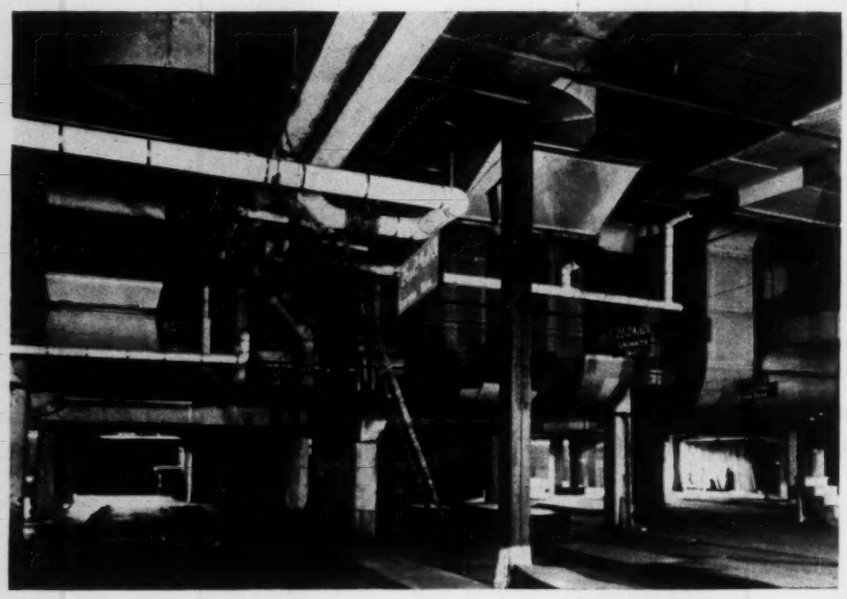
A second fan and duct system exhausts the air, which has a temperature of about 70 F, from the office spaces and supplies it to the storage areas, thus conserving the heat in the air for re-use in the protection of stored galvanized and full finished sheets of all kinds, mechanical tubing, and other steel commodities.

Whenever stored metal is appreciably cooler than the air which comes in contact with it, moisture condenses out of the air and causes rust and stains. This occurs in summer as well as in winter whenever the temperature of the metal reaches the dew point of the air. It is the same interesting phenomenon that is evidenced in moisture outside a glass of cold water on a warm day, and in white frost on hinges and latches on outside doors on cold winter mornings. Ryerson discovered long ago that this damage could be prevented by application of heat at the right time, and maintains the necessary instruments and equipment to deliver the heat before the dew is laid down. While the heat in the exhaust air from the office system is sufficient during much of the time, steam convectors capable of increasing the temperature of the air are provided.

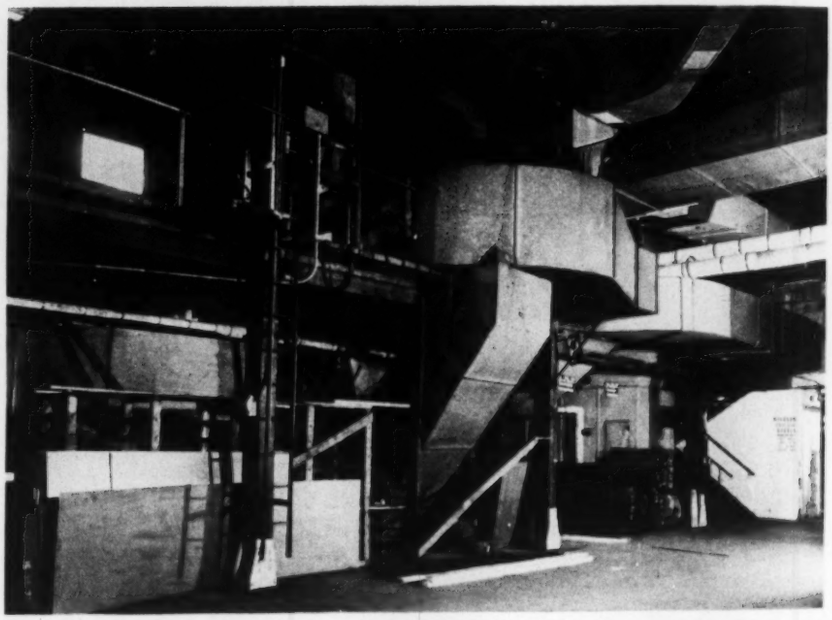
Steam is supplied the offices and warehouses by a plant comprising three large water tube boilers fired with pulverized coal. The air for combustion purposes is preheated in the hollow walls of the combustion chambers. The entire coal and ash handling equipment is mechanical, including even the removal of dust from the breeching.

Samuel R. Lewis has been the

Above—Some of the duct work in a storage area, furnishing the warm exhaust air which has been taken from the offices. Under ordinary conditions, the piles of sheets in storage would be head-high or more



Here are the ducts which supply filtered ventilation air, heated and humidified in winter, to the offices, and some of the ducts which convey the exhaust air to storage areas. In the background is the supply fan and continuous viscous air filter



The fan on the platform and the ducts shown here exhaust air from the offices and supply it to the steel storage warehouse. When additional heat is needed, convector heating surfaces raise the air temperature

consultant on the installation of these heating and ventilating systems.

Before the present arrangements for heating the steel storage spaces were developed they were heated by wall-hung pipe coil radiation. In recent years, much of this pipe coil surface has been replaced (in steel storage areas not served by the exhaust air system) by unit heaters which distribute the heat more effectively. Due to the great need for scrap metal, these old and unused pipe coils are now being salvaged. Before the present war the cost of removal exceeded the salvage value and the pipe coils were left in place. At present, however, Ryerson feels it a patriotic duty to return all scrap of any kind to the steel mills to help out in production for victory.

Ryerson, now celebrating its 100th anniversary, has war experience dating back to the Revolutionary War, when mines and forges owned by the Ryerson family furnished some of the iron used in the chain which blockaded the Hudson River at West Point. In World War I, Ryerson received a citation for distinguished war work, and in the present war is actively cooperating with the government in introducing new low alloy steels (National Emergency steels) to industry. All 10 plants of Ryerson are devoted almost completely to supplying steel for war purposes.

PIPE FITTINGS FOR SPRINKLER SYSTEMS

Permission to manufacture types of pipe fittings necessary for the operation of fire protection sprinkler systems and for drain pipes was granted by the WPB director general for operations in amendment 3 to schedule II of limitation order L-42, issued last month.

INDUSTRIAL HEALTH FOR DEFENSE

The division of health and social services of the Massachusetts committee on public safety, 18 Tremont St., Boston, recently issued a manual on industrial health for defense and is distributing 25,000 copies of it. Confined to the most important phases of industrial health, the booklet has much of value and interest and includes numerous references to more complete sources.

FOR VICTORY—
SAVE . . .
SIMPLIFY . . .
SUBSTITUTE

U. S. Maritime Commission photo

Stowing general cargo in the hold of a merchant vessel

Prefabricated Piping Speeds Shipbuilding

Oregon Shipbuilding Develops Method of Simplifying Piping Installation

SUMMARY—Under a new plan developed at Oregon Shipbuilding, piping installations are largely prefabricated and go into hulls in complete units with greater precision and efficiency than previously possible. A loft was converted into a full scale model of the machinery area on a ship, and the piping systems designated by colored lines on the floor. Elevated jigs are used which correspond to actual openings and fittings on the ship's machinery and equipment. These jigs are painted to correspond to the proper piping system. . . . This prefabricating plan has broken several bottlenecks in shipbuilding, a job which is vital to victory

IN THE good old days, pipe was bent, cut and fitted according to blueprint specifications, then hoisted into hulls piece by piece where it was adjusted, welded and bolted into position. Quite often variations in machinery space construction meant trouble. Welding and fitting had to be done under crowded conditions in almost inaccessible places.

Under a new plan developed at the Oregon Shipbuilding Corp. by Chester Spiering, pipe assembly superintendent, with the help of the marine machinists, shipwrights and drafting department, piping installations are largely prefabricated and go into hulls in complete units with far greater precision and efficiency than was previously possible.

Converting a 60 x 280 ft loft into a full scale model of the machinery space area on a ship, Spiering and his crew first laid out his floor space, designating by a system of colored lines on the floor the five systems of piping which his department prefabricates.

The same color identification is carried out to the markings on the pipe itself which leaves the pipe assembly with adjoining sections clearly numbered and striped in the proper color. So that the pipe will conform to the floor lines and diagrams, a series of hangers elevate the sections in place while they are being fitted.

The second feature of this plan is the use of elevated jigs which correspond to actual openings and fittings on the ship's machinery and equipment. These jigs are metal frames with the names of the pieces they represent clearly indicated. These are also painted to correspond to the proper piping system. They are adjustable both vertically and horizontally, enabling the workman to adjust them to conform to changes in ship's specifications.

In the pipe assembly, adequate space is provided for a crew of 40 or more welders and pipefitters who put on flanges, weld connections, adjust lengths, and otherwise handle about 85 per cent of the pipefitting which previously had to be done in the hulls.

The development of this prefabricating plan has broken more than one bottleneck in pipe installation. Beside cutting down welding time almost 85 per cent, it has helped to relieve congested working conditions in the machinery space of unfinished hulls—also the hazard of metal fume fever has been eliminated.

It has also helped cut down transportation time by eliminating most rejected material and has enabled hulls to receive pipe installations in complete systems.

It has reduced losses due to breakage and errors and made fitting more accurate.

Next step, says Spiering, is to handle overhead installations and further cut down production time.

INSTALLATION AND SERVICE INSTRUCTIONS FOR REFRIGERATION CONDENSING UNITS

A Proposed Commercial Standard for Commercial Electric Refrigeration Condensing Units (TS-3300), adopted at a manufacturers' conference in June and circulated to the industry for comment, establishes minimum specifications and test methods for the guidance of manufacturers, distributors, installers, contractors, and users. It covers air cooled and water cooled units from 1/5 to 3 hp, and water cooled models of 5 hp.

It is recommended in the standard that a copy of the following installation and service instructions be furnished with each refrigeration unit:

Place unit where it has a free circulation of cool air. If a watercooled unit, do not install where it will be subjected to freezing temperatures.

Lubricate motor bearings before starting unit. Use only lubricant of the grade recommended by the motor manufacturer.

Check nameplate on motor and controls to be certain that unit is being connected to correct current.

Use line fuses of proper rating (See National Electrical Code).

Make certain that pulleys are in alignment and that belt is adjusted to proper tension.

Check direction of rotation of compressor as indicated by arrow on unit.

Be sure evaporator and lines are dry and clean. If they have stood open, blow out with CO_2 and bake dry.

The use of a suction or liquid line strainer for protection of the system is recommended.

Use only suction or liquid line dryers to remove moisture. Use dryers which have been recommended by the compressor unit manufacturers.

Draw a deep no-bubble vacuum on the entire system before charging with refrigerant, using a vacuum pump designed for that purpose.

Check the compressor oil level after unit has operated a few hours, and add oil as required to make up for that in the lines and evaporator. Use only clean, dry oil in sealed cans approved by the manufacturer of unit.

Test all joints for leaks. Use a good halide torch leak detector for methyl chloride and "Freon" and a strong ammonia swab for sulphur dioxide.

Check adjustment of expansion valve and reset if necessary to keep liquid refrigerant from returning to the compressor. Be sure to use the proper size valve.

Use only refrigerant specified on unit nameplate that is clean and dry. If refrigerant is changed on approval of the unit manufacturer, remove old refrigerant and compressor oil, put in new approved oil, and pump a deep vacuum before charging with new refrigerant.

Before leaving the installation as complete, recheck temperature, valve settings and general operation, always using gages. See that service valve caps, control covers, and other loose parts are in place. Also recheck pressures, compressor oil level, and the motor oil.

Instruct the customer or user in the care and operation of this unit; how to oil motor and replace fuses. Leave your name, address and telephone numbers, day and night, posted near the unit.

HAZARDS TO EYES INCREASE

Ninety-eight per cent of the eye injuries which occur in American industries at a rate of 1000 a day and represent an annual loss of $200,000,000 are wholly unnecessary, according to a study sponsored by the National Society for the Prevention of Blindness and recently issued by the Columbia University Press. Price of the book is $3.50. It was prepared by Louis Resnick.

A serious factor contributing to the inadequacy of official records of eye injuries is the rapidly spreading use in industry of poisonous chemicals and other deleterious materials which cause damage to the eyes. In many instances neither the workman whose eyes have been affected nor his physician knows that the worker has been exposed to poisonous fumes, liquids or dusts.

DEPUTY CHIEF OF WPB HEATING BRANCH APPOINTED

Appointment of Ronald Allwork as deputy chief of the WPB plumbing and heating branch has been announced by W. Walter Timmis, chief of the branch. Mr. Allwork has been chief of the branch's planning and projects section since February of this year. Before joining the War Production Board staff, he was a specialist in the preparation of specification data for building products. He has been associated with many companies in the heating and plumbing industry, and was connected with the Red Hook Housing development in New York City as a designer.

The duties of the planning and projects section will be consolidated under Arthur L. Rayhawk, as chief of a new production requirements section.

Heating · Piping · Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

FUEL CONSERVATION

All fuel users have the opportunity of making a personal contribution towards winning the war. The fuel oil shortage on the East coast and in the Pacific Northwest is considered to be imminent. The increased demand of other fuels by war industries, and the consequent shortage, presents a serious problem in other sections of the country. Unless some foresighted planning is adopted immediately there is apt to be a number of cold offices, hotels, apartments and residences this winter.

Four general plans of coping with the situation are recommended. **First,** in those areas where a fuel shortage is known to exist, it is important for all who can to convert **now** and burn a more readily obtainable fuel. **Second,** everyone should take **immediate** steps to conserve fuel by installing storm windows and doors, applying wall and ceiling insulation, and caulking or weatherstripping wall or window openings. **Third, before** cold weather comes, have a competent engineer or contractor survey the heating plant and make sure that the boiler or furnace is operating efficiently. **Fourth, after** winter comes, take every precaution possible to conserve fuel.

In sponsoring the **War on Fuel Waste** throughout the nation, the ASHVE is desirous of focusing attention on the necessity of saving fuel as a war measure. Every pound of fuel saved relieves the strain on the transportation facilities of the country and allows the more critical fuels to be utilized for the important products of war.

It is a patriotic duty to **War on Fuel Waste,** and at the same time substantial personal savings will result.

WAR SERVICE COMMITTEE

B. M. Woods, **Chairman**
W. A. Danielson
W. L. Fleisher
E. Holt Gurney
Thornton Lewis
A. C. Willard

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War On Fuel Waste Week

Fuel Conservation

Walter L. Fleisher
New York, N. Y.

Hon. Fiorello H. LaGuardia
New York, N. Y.

M. F. Blankin
Philadelphia, Pa.

THE *War on Fuel Waste Week*, sponsored by the War Service Committee of the Society, was inaugurated with a forum and luncheon-meeting at the Hotel Pennsylvania, New York, Monday, August 17, with over 100 members of the ASHVE, trade association representatives, and others in attendance. Walter L. Fleisher, consulting engineer, New York, presided at the morning meeting and his complete introductory remarks are recorded on this page.

M. F. Blankin, Philadelphia, first vice-president of the Society, was toastmaster at the luncheon following the morning session, where the Hon. Fiorello H. LaGuardia, Mayor of the City of New York, was the featured speaker. An abstract of the Mayor's address will be found on the opposite page.

The first speaker at the forum was Ned Foulds, New York, N. Y., Chief, Fuel Oil Section, Petroleum Coordinator's Office for War. He spoke on *Fighting the Fuel Oil Shortage by Conversion*, which is printed on page 561. W. Walter Timmis, Chief, Plumbing and Heating Branch, War Production Board and a member of the ASHVE, discussed the subject of *Equipment for Conversion and Conservation*, and this is abstracted on page 564.

Joel Dean, Washington, D. C., Rationing Chief of OPA, sent a message to the meeting in the form of a telegram, which is printed on the opposite page. *Coal for Victory* was the subject of an address by Dr. Luther Harr, Washington, D. C., Bituminous Coal Consumers' Counsel, and the full text of his remarks will be found on page 563.

Dr. C.-E. A. Winslow, New Haven, Conn., a member of the Council and vice-chairman of the Committee on Research of the Society, presented an informal discussion of *The Problem of Maintaining Health and Comfort in a Period of Fuel Shortage*. Dr. Winslow stated that the essential quality of a satisfactory thermal environment is that it should carry off the heat produced in the human body by chemical oxidations involved in those physiological processes which are called *metabolism*. Since metabolism increases rapidly with physical work the optimum air tem-

INTRODUCTORY REMARKS BY W. L. FLEISHER

The War Service Committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS has called this meeting to inaugurate "War on Fuel Waste" Week and is pleased to welcome this group. At the request of Secretary Ickes, our Committee with the assistance of all interested groups has made a profound study of the fuel situation. It has brought about greater cooperation than was considered possible. It is convinced that there will be a shortage of fuel oil, notwithstanding the conflicting statements that various agencies report to the papers and directly to the public, and that the only way unnecessary and real discomforts can be avoided this winter is by eliminating waste and by substitution of one kind of fuel for another, and by the cooperation of the Government and the public in an appreciation of these facts.

There *never* was an excess of oil on the Eastern seaboard, notwithstanding anything that anyone may say to the contrary—see Secretary Ickes' own statement in last week's Collier's, "if the total amount of fuel delivered on the East coast was available this year, a large amount of this fuel should be sent abroad or used for refuelling our ships. Much of this required amount can and must be saved." If there is division of opinion between the WPB, the OPA and the Department of the Interior, they should settle their indecisions in secret chambers and not before the public. I can assure you that at least one of our agencies considers rationing of fuel oil not only possible, but almost certain.

The investigations of the War Service Committee have convinced us that the remedy lies in our own hands, to a major extent. Words of optimism will not keep the cold out of our homes. It is the purpose of our fuel conservation campaign to tell the public what to do and what to expect. Ours is a patriotic duty without thought of political, commercial or financial gain. We welcome the constructive advice and assistance of all of you in the inauguration of this "War on Fuel Waste" Week and hope that you will carry the plan forward in your community.

This morning we have a group of distinguished speakers from the fields of engineering, public health and Government, who will give you some vital facts on the fuel situation and the remedies that are under discussion.

perature must also vary widely. In planning for the heating of occupied dwellings, Dr. Winslow mentioned that it is impossible to count on active physical work; however, there are important variations in the normal resting metabolism of persons of different ages and physical states, which must be considered.

He indicated that in most rooms there are distinct regional variations caused by radiation to cold walls and particularly by differences in air temperature at various levels. It is for this reason that the Committee on Hygiene of the *American Public Health Association* has fixed as a minimum limit for normal human occupancy a temperature of 65 F at knee height, which corresponds generally to 70 F at face height.

Dr. Winslow also referred to the fact that a child of six years of age has a higher metabolism in proportion to its surface area than an adult, and for that reason young children whose physical activities are likely to be considerable can be comfortable with a minimum mean temperature of about 67 F. On the other hand, he stated that for infants and for the old and infirm, metabolic rates are below normal, and for such individuals the minimum temperature at face height should not fall below 73 F.

It was his opinion that much fuel may be saved by adjusting room temperatures to meet actual occupancy needs. In the morning when the housewife is the only occupant and if she is engaged in active physical work, the maintained temperature may be low. However, in the evening when the family is at rest it must obviously be increased.

Dr. Winslow advocated the installation of storm sash and insulation as a means of reducing heat loss to a minimum in the home, offering the family more protection from cold. He also discussed the problem of providing localized zone radiant heating as a supplement to the present available general heating systems.

He called attention to the fact that perhaps one practical method of protecting health during the coming winter would be found in the wider use of clothing which would be selected for its higher insulating values.

As a word of caution, Dr. Winslow concluded his remarks to the effect that if we do find it necessary to limit room temperatures this winter, it is important that everyone should *play the game*. Those who conserve fuel in their homes and compensate by wearing warm clothing should not be exposed to higher temperatures in other homes, schools, stores and the like. He felt that great discomfort and danger to health may result from contrast effects which occur when a warmly clad person is bathed in perspiration in a warm room and then goes into a cold one.

The Fuel Oil Problem*

By Hon. F. H. LaGuardia,
Mayor of New York City

THIS FUEL problem is just one of the many serious matters that will confront us in the course of the war and it illustrates perfectly how unprepared we were at the beginning of the struggle. Fortunately, our people can meet any demand that is made upon them, but when the machinery is to be turned in reverse and we are asked to conserve, after being considered the most wasteful people on the face of the earth, it is a difficult task for everyone. Under such circumstances I fear some hardship and suffering must be expected before we meet all the requirements and demands necessary for a successful termination of the war.

You will recall that a year ago Mr. Harold Ickes warned the country of the necessity of conserving fuel oil. Everyone declared him to be an alarmist and thought the whole problem of fuel conservation was unnecessary. However, the City of New York immediately made a thorough survey at that time and agreed with the conclusions of Secretary Ickes. Then, nothing happened and we abandoned the whole subject for the rest of the summer and continued to burn fuel oil. Even before Pearl Harbor we were losing tankers, and soon the loss of tankers increased, due to submarine warfare. In view of the fact that the supply of fuel oil comes to New England by oil tankers from the fields of the Southwest, this problem of tanker loss was basically the cause of our present trouble.

Without any preparations we immediately had to consider a substitute means of transportation, and you all recall the controversy that raged between the railroads and other means of transportation at the time, and a lot of time was lost. Last June I called a conference of the Mayors of the 17 Atlantic States and we attempted to cope

*Abstract of address presented at luncheon-meeting sponsored by the War Service Committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Hotel Pennsylvania, New York, N. Y., August 17, 1942.

TELEGRAM

MR. A. V. HUTCHINSON, SECRETARY
AMERICAN SOCIETY OF HEATING AND
VENTILATING ENGINEERS
51 MADISON AVENUE, NEW YORK, N. Y.

DEEPLY REGRET THAT IMPORTANT CONFERENCE CALLED BY MR. HENDERSON PREVENTS MY APPEARANCE ON YOUR PROGRAM TO TALK ON PREPAREDNESS FOR FUEL OIL RATIONING. SERIOUS FUEL OIL SHORTAGE ANNOUNCED BY SECRETARY ICKES HAS CAUSED US TO START EXHAUSTIVE STUDIES OF THE MANY PROBLEMS IN PLANNING RATIONING IN THE EVENT WE ARE CALLED UPON BY THE WAR PRODUCTION BOARD TO ACT. OUR JOB AS YOU KNOW IS NOT TO DETERMINE WHAT WHEN OR WHERE TO RATION BUT HOW AND WHO TO RATION. APPRECIATE THE GREAT HELP ALREADY GIVEN US BY MEMBERS OF YOUR ORGANIZATION AND HOPE WE MAY HAVE YOUR CONTINUED COOPERATION IN ANY WAR MEASURES ORDERED IN THE INTEREST OF OUR COUNTRY IN THIS STRUGGLE AGAINST THOSE WHO SEEK TO DESTROY US.

JOEL DEAN, DIRECTOR OF FUEL RATIONING
OFFICE OF PRICE ADMINISTRATION,
WASHINGTON, D. C.

enal transport in this emergency.

But, gentlemen, their combined capacity still leaves the East considerably short of the total oil supply that we shall need throughout the coming winter.

The slack must be taken up. War needs must and will be met. The ships must move, the planes must fly, the tanks and guns on the battlefronts must have their oil, they can't use coal . . . what oil is left is all there will be to keep us civilians driving to work and heating our homes. And that margin, as it looks today, is not going to be enough.

Can we stretch that margin so as to avoid serious distress in East Coast homes next winter? I think we can, and I believe that you'll agree with me. But the job can only be done by fast, generous patriotic conversion of oil-burning equipment to the use of coal, and by the most rigid and complete conservation of fuel and heating oil this country has ever seen.

War has created a challenge for you of the heating and ventilating business, and for you whose job it is to guard the community health, that is the dream opportunity of a lifetime.

It would be crude business policy for any one here to look upon the possible distress of thousands of families as the keystone of a bonanza for the insulating business. But the job we must do—and do fast—is stimulating home and plant improvements for the conservation of fuel and heating oil. This will create a quick market the magnitude of which is anybody's guess. I will wager that most of you have been doing some night work on that little matter, to make sure your prices are patriotically low.

But the job itself is far more important than any personal balance sheet. Believe me, gentlemen, we must secure the homes and families of the East Coast against a fuel oil shortage that can mean great distress.

This is no prediction—only a fool makes predictions in wartime—but the irony of our position as we consider this problem today is this: exactly to the extent that we are successful in stimulating conversions of power and heating equipment to the use of coal, exactly to that degree do we relieve the threat of distress.

Never fear, the better the job we do in shifting consumers away from oil, the more likely is it that we shall later be labelled prophets of distress that never came.

For my part, I shall not be unhappy if by dint of having helped avert the threat of cold, unhealthy homes next winter, someone accuses me of having cried *wolf*.

The facts are clear and cold—fuel and heating oils are seriously short here along the Atlantic Seaboard and there is no assurance that we can build up or maintain fuel oil stocks to provide even for minimum needs.

I am crying *wolf* because I can see him coming. And if some quirk of fortune clears the U-boats from this coast, or helps the rails carry more oil than seems physically possible now, or if fuel and heating oil consumers can be induced to convert and conserve oil in greater volume than can be reasonably expected, or if perchance some cosmic comedy brings us another mild winter—if all these things should happen and turn the wolf of shortage away from our terminals and our oil tanks, then I will say there is a Santa Claus, and you can call me anything you like.

Right now we cannot afford to count on Kris Kringle. We have to go out and get folks to convert every last oil burner we can from the use of oil to the use of coal. That is a hard statement for me to make—me an oil man who spent many years promoting oil sales through the installation of oil burners—but oil is ammunition and we must supply our armed forces with ammunition. Barring conversion as a practicable solution for the individual consumer, we've got to help him make every preparation for cutting down consumption.

That, gentlemen, is the task that your Government asks you to do—and do now. Stress conversion first. It represents the safest insurance against shortage for the individual family, plant or commercial establishment.

As you know—and as three separate, independent surveys have shown—slightly more than 50 per cent of all the 1,423,000 domestic oil burners now in use in the Atlantic Coast States were previously converted from coal to oil. And grates and shaker bars are still on hand in more than 18 per cent of those homes.

There is your initial market for conversions. Eighteen per cent of 1,423,000 is 256,000 homes where conversion can be a relatively simple and inexpensive job. And please do not jump and yell: *What about lugs?*—if a couple of lugs are going to keep one of your customers cold next winter then you ought to go cold along with him. There are alternate methods of converting a lug-less furnace, and you men know it. The cost is slightly more, yes. But this shortage situation is critical, gentlemen. There *is* a war in progress.

If those 256,000 homes are converted to coal the equivalent of 12,800,000 barrels of oil would be saved—and almost all of it during the heating season proper. Those 12,800,000 barrels of fuel and heating oil saved would release many tank cars from fuel and heating oil transport and make them available for carrying more crude and other more war-essential products.

Those potential conversions of domestic equipment mean two things: *first*, security against wintertime distress for those who convert and make immediate arrangements for getting the necessary coal into their cellars. *Second*, it means a vast and essential contribution to the whole war job.

If personal interest and patriotism ever had a better chance to team up and get a job done I never heard of it.

Gentlemen, go back to your accounts and get the job done.

That's not me speaking the challenge—it is your President, who told Coordinator Ickes:

> I earnestly hope that every citizen will realize the serious uncertainties which cloud our prospects for petroleum supplies on the Atlantic Seaboard next winter. Whatever action he may decide to take, every user of fuel and heating oil should face realistically the fact that there can be no guarantee that he will get enough oil to meet even his minimum needs.

That was the President speaking. That is the challenge you face—the essence of your responsibility to your customers, your industry and the country in this critical time.

I think I need not emphasize the fact that you of New England's icy winters have an especial task cut out for you. Currently New England's

stocks of fuel and heating oils taken as a whole are proportionately more satisfactory than those throughout the Eastern area generally. But it is a long haul from the refineries to Newport, Vermont or Bangor, Me., or even Rutland or Concord. And the charm of your blizzards and your ski slopes can be dulled pretty fast if the cottage or hotel isn't warm and cheery. Even those shallow old comforters — your New England fireplaces — can't do the job of a good hot bed of coals in the furnace downstairs.

Now—what about coal?

The men of solid fuels assure us that there can be adequate anthracite to meet the needs of converted furnaces *provided*—and this is paramount—that coal is ordered now and stored now. Every week's delay in getting the anthracite stock pile built for next winter reduces by about 200,000 tons the potential available supply. The need is for action—now. And that is part of the conversion job that cannot be slighted. Families who convert should assure themselves of the availability of coal and then *get it fast!*

I have stressed conversions because they represent the wisest, safest insurance against a cold home next winter. And that, I take it, is the chief interest of you who are concerned with community health. Let us take the wisest course first. Where conversions are not practicable—then bear down on all conservation measures.

There is little point in my discussing fuel conservation measures with you. You are the men with the *know how* to analyze, recommend and install the right conservation elements for the maximum advantage of the individual consumer. Go to it. Converted or unconverted, almost every home is a prospect for your art, your ability and your products.

Get every possible home converted from oil consumption to the safer heat of coal. Then let us caulk every cranny and bar every door and window and roof against the leakage of every possible drop of fuel—oil or coal.

Your Government and the petroleum industry are now speeding the conversion - conservation campaign with every tool at their command. Many of you are already familiar with the efforts that are in the works. We need your help and need it plenty—if we are to succeed in keeping the fuel oil shortage from seriously impairing the health, vitality and morale of our civilians-at-war along the Atlantic Coast.

A lot of folks have been begging for a bigger job to do in helping win this war—gentlemen, here's yours!

Coal for Victory

By Dr. Luther Harr,* Washington, D. C.

IN ORDINARY times I would hesitate to speak before a society of engineers, not being an engineer myself, but I am very glad of this opportunity to participate in your nation wide coal conservation program.

The Office of the Bituminous Coal Consumers' Counsel is unique among government agencies in that its work is devoted solely to the interest of the consuming public. It is an entirely independent executive agency, under no other department, but reporting directly to the President and to the Congress. Originally established to afford to the consuming public protection against inequity in the administration of the Guffey Coal Act, it has become, in war times, the public safe-guard against actions by other public and private groups, which, while legitimate in themselves, sometimes fail to take into account the consumers' interest.

Parenthetically speaking, it should be apparent that as the stress and strain of the war effort increases,

Dr. Luther Harr

government must take an increasingly important role in the life of business and therefore in the welfare of the lives of individuals. Producers are well represented at Washington by powerful organizations; labor too is well organized and well represented. The consumer is neither organized nor has he powerful groups representing him. The Bituminous Coal Consumers' Counsel is the only independent government agency representing consumers now operating. Perhaps the time will soon come when consumers of other important commodities will likewise have official representation to protect their welfare in the critical months ahead of us.

The Consumers' Counsel guards against imposition of prices which would place an unfair burden on the consuming public in increased freight rates which would increase the price of coal to the home owner and manufacturer and against practices which would cause distress to any community or any group. For example, the Acting Director of the Bituminous Coal Division is about to adjust the minimum mine prices for bituminous coal that will give effect to increased costs. The proceeding, upon which the Director's action will be based, has been in progress for over a year. Our office has taken an active part throughout, being represented by experts who have had years of experience in the production and distribution of bituminous coal. While this is a most important function, it is not the only function.

Since this office was originally established, it has consistently taken the position that the consumer should have as much information as possible about the qualities of coal, so that he could select that coal that would give him the best value for his coal dollar if he was an industrial consumer, or that coal that would be most economical and at the same time give him the degree of comfort

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Presented at *War on Fuel Waste* Week Forum sponsored by the War Service Committee of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Hotel Pennsylvania, New York, N. Y., August 17, 1942.

he desires if he were a domestic consumer. While this function is most necessary, it is felt that the office is under obligation to go a step further with respect to domestic consumers, at least. If the latter does not know how to burn his coal or does not know how to keep his heating plant in good condition, the result of proper selection of coal will be more or less nullified. With this in mind, this office prepared a bituminous coal chart which some of you may have seen. This chart attempts, by diagrams and simple instructions, to point out to the consumer proper methods for burning his coal. This chart has been reproduced by retail dealers, marketing agencies, etc. An arrangement has recently been worked out for the publication of 250,000 by a prominent marketing agency. Other charts have been published and our technical advisers have been called upon to pass on some of these charts before publication.

For the past few months this agency has been showing throughout the nation a film titled *Coal for Victory* which has emphasized the importance of coal in the war effort. During the present war time conditions, the education of the consumer in the efficient use of coal and in the proper maintenance of his burning equipment cannot be over-stressed, and I want to emphasize the responsibility that devolves on your Society in this respect. You are the men who have as great a responsibility as any other group in seeing that the waste of coal, due to improperly maintained equipment and improper firing methods is kept to a minimum during the burning season. In any of your deliberations, one should keep in mind the vastness of the government frame-work. It is felt that none of you will be like the young stenographer who arrived in Washington last week from a western state: When she took a taxi at the Union Station and the taxi driver asked where to, she replied: To the Federal Building. The more you can do that does not require decisions by the government, the more effective your work will be.

The office of the Bituminous Coal Consumers' Counsel has just recently issued a pamphlet in which it outlines 4 methods of coal conservation. There are steps to be taken now which cannot be done when the snows come without great discomfort if they can be accomplished at all. They will require the outlay of some funds, but the money so spent will be recovered through savings in coal bills. They will require the expenditure of some time; but every patriotic American will give time to help win the war. And if these steps are taken now, on a wide scale, they will produce enough savings of fuel to ease the pressure on the transportation system and virtually insure the homes of Americans against suffering.

The four major steps recommended to homeowners are:

1. Insulation, partial at least, complete if possible.
2. Installation of storm doors and windows.
3. Use of non-metallic weatherstripping.
4. Complete overhaul of heating equipment.

Complete insulation of homes will produce much savings in fuel. Storm doors and windows, by eliminating loss of heat through the glass, offer another important method of saving fuel. For those who cannot afford storm doors and windows, non-metallic weatherstripping affords an economical, do-it yourself method of saving fuel. Every homeowner should have his furnace overhauled and put in first-class condition. A few dollars spent to employ a good furnace man to overhaul equipment will be paid for in a short period out of fuel economies.

While the functions of the Office of the Bituminous Coal Consumers' Counsel are by a statute confined to the problems of bituminous coal consumers, it has not hesitated during the present war period to make available to other agencies, governmental and private, its facilities. The fuel experts on the staff in this office are frequently called upon for advice and criticism on fuels other than bituminous coal as it is felt that during these times one must share with the other his experience, knowledge and facilities. For example, the technical advisers of this office have recently been in frequent consultation with OPA in the preparation of an anthracite chart that I understand will be issued in the near future and will give information on the proper use of anthracite and maintenance of equipment somewhat similar to our bituminous coal chart.

In conclusion, the Office of the Bituminous Coal Consumers' Counsel is at your service. None of us know with certainty what the situation will be next mid-winter. Steps in the right direction now will be insurance against physical suffering when the thermometer hovers around zero.

It is known that coal as a major source of fuel energy in this country is a most important factor in winning the war.

Our people must be educated daily concerning the importance of the part they can play to help to bring about victory by using coal carefully and wisely.

Equipment for Conversion and Conservation

By W. Walter Timmis*, Washington, D. C.

AT LEAST two months ago we recognized the impending fuel oil shortage and we did our best to prepare the country for the necessity of taking conversion and conservation measures. Consequently, a great deal of work has already been done. Working in cooperation with the Petroleum Coordinator's Office we were able to obtain a very clear picture of the oil situation. With this information we presented the case to the War Production Board, which is charged with responsibility of alloting the already short supply of critical materials.

Due to the fact that the heating conversion problem necessitates the use of critical materials, the solution to the problem presented is almost unsolvable, because of the limited supply of material. To effect con-

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Abstract of address presented at the *War on Fuel Waste* Week Forum sponsored by the War Service Committee of AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, Hotel Pennsylvania, New York, N. Y., August 17, 1942.

version from oil to unrestricted fuels, such as coal, it takes such critical materials as iron, steel and copper. At the present time there is not enough of these materials to go around, and yet we find the necessity of allocating the minimum requirements in order to take care of the absolute necessities. This whole matter was fully discussed in several meetings of the Requirements Committee of the WPB in Washington, at which there were representatives of the Petroleum Coordinator's Office, the Office of Defense Transportation, Solid Fuels, Office of Price Administration, and various other people of the Government concerned with the allocation of critical materials.

Fortunately an allotment of 11,000 tons of iron, steel and other materials was made available for this conversion problem. Admittedly this is not enough material to effect the complete conversion program which is contemplated by the Office of Petroleum Coordinator, but the Requirements Committee feels that this is all that can be allotted at the present time. This means that there will have to be very careful planning in the distribution of the available material so that it can be utilized in the most advantageous manner. This allocation includes materials for stokers to be installed in commercial and industrial applications, includes industrial combustion equipment, coal-handling devices; it includes material for grates, lugs, fire doors, and shaker bars for domestic conversions; and whatever other special equipment is needed.

Of the 11,000 tons which have been allotted it is contemplated that there will be enough material for converting about 72,000 domestic installations. The Oil Petroleum Coordinator's Office has indicated that it is desirable to convert about 200,000 domestic plants, which means that every one who has equipment on hand must convert first.

Conversion grates are now being manufactured and will be available through the normal channels of the

W. Walter Timmis

industry. The manufacturers of furnaces and boilers who normally make grates as repair parts for their equipment have applied to us on the production requirement plan for the material to make grates, and we have granted it to them for this particular purpose. For large installations, applications are made through Form PD-200, and arrangements have been made in the War Production Board, so that all of these projects clear through the Plumbing and Heating Branch. At the present time we are using the dollar value of the amount of fuel to be saved as a means of gaging the amount of critical material that should be allocated to such applications. We recognize that this is not a reliable index, but it is the best that we can use for the want of something better at the present time.

Domestic stokers that are now available in stock can be sold without priorities, but of course, no additional stokers can be manufactured at the present time. For commercial and industrial stokers a priority must be obtained on Form PD-1-A. If it is a particularly large installation involving a good deal of construction, coal storage and handling equipment, etc., such requests must be presented on a project application, because we need more information than can be furnished on the PD-1-A application.

Of course, we are being confronted with a number of suggestions from people all over the country to provide materials for manufacturing all kinds of gadgets for saving fuel. Unfortunately, each one of these individuals feels that he has the whole answer to the fuel problem. One suggestion is that if a draft regulator is installed in a heating plant the whole fuel problem will be solved. We all know that if every installation in the country included one of these draft regulators it would be unnecessary to convert plants at the present time. From other sources we are urged to have everyone install temperature controls. From other sources, if you will only provide the fireplace with basket grates to burn coal, the whole situation would be relieved. We have had applications to make at least 500,000 damper motors which is a greater number than have been made in this country in any previous period.

Unfortunately, the situation cannot be met this way. We do not believe that it is proper to furnish the requested material for all these gadgets. This fuel oil shortage should not be used as a means for promoting the sale of all these devices. When fuel was plentiful the industry could not get people to buy such equipment. Now that we have a real shortage of fuel, both oil and coal, we do not feel that this is the opportune time to promote such equipment.

This whole problem must be attacked solely on the basis of conversion wherever it is possible and with the very minimum use of critical materials. We know that if people will just operate their plants sensibly they can make tremendous savings by reducing the thermostat setting at night; by reducing the temperature on mild days; by turning the heat down when away for a week-end or several days; and by reducing the temperature during the middle part of the day. There are many measures that can be taken, such as these, aside from improving the efficiency of the burner and improving the heat-retaining qualities of the house itself. Those are the things that it is up to you to bring to the attention of the public. Just how it can be done is a real and practical problem.

Fig. 1—Standard elbows

Effect of Vanes in Reducing Pressure Loss in Elbows in 7-Inch Square Ventilating Duct

By M. C. Stuart,* C. F. Warner,** and W. C. Roberts†
Bethlehem, Pa.

This paper is the result of research sponsored by the American Society of Heating and Ventilating Engineers in cooperation with Lehigh University

SUMMARY—Paper covers an investigation of a 7x7 in. square elbow with round and square inside and outside corners and various radius ratios. Data reported show reduction of pressure loss in elbows by the use of vanes and splitters. Visual flow patterns in elbows are shown utilizing a *schlieren* apparatus

Introduction

This is the second of a series of papers dealing with pressure loss caused by elbows in ventilating ducts. The first paper, presented by the authors (17)†† described the method of measuring pressure loss, developed a method of expressing pressure loss of an elbow as equivalent length of duct, and reported upon pressure losses in elbows without vanes in 8-in. round ventilating duct. Reference should be made to this previous paper for a description of the apparatus and method of investigation used.

The present paper presents the results of an investigation of elbows of one aspect ratio in 7 x 7-in. square duct, and in particular studies the effect of various forms of vanes in reducing the pressure loss in the elbow.

Pressure Loss in Radius Elbows Without Vanes

Apparatus for the study of the pressure drop in a single elbow consisted of a fan, discharge box, 30 ft of approach duct, the elbow under investigation, 105 ft of discharge duct, plenum chamber, and measuring nozzle. The duct was made up of standard 5 ft sections fastened by the Pittsburgh lock which was taped to prevent air leakage. Elbows of various radius ratios were tested at velocities ranging from 400 to 4000 fpm. The radius ratio of an elbow is defined by the equation:

$$R/W = 0.5\,\frac{1+\frac{R_1}{R_0}}{1-\frac{R_1}{R_0}}$$

in which

R = mean radius of elbow
W = width of elbow in plane of bend
R_0 = outside radius
R_1 = inside radius.

The standard elbows (without vanes) tested in this part of the investigation are shown in Fig. 1. Table 1 gives the dimensions of the elbows shown in Fig. 1.

Curve A of Fig. 2 indicates that as the radius increases, the additional equivalent length (corresponding to the pressure loss) decreases until a constant value of equivalent length is reached at a value of 28 in. or greater inside radius. The additional equivalent length is defined as:

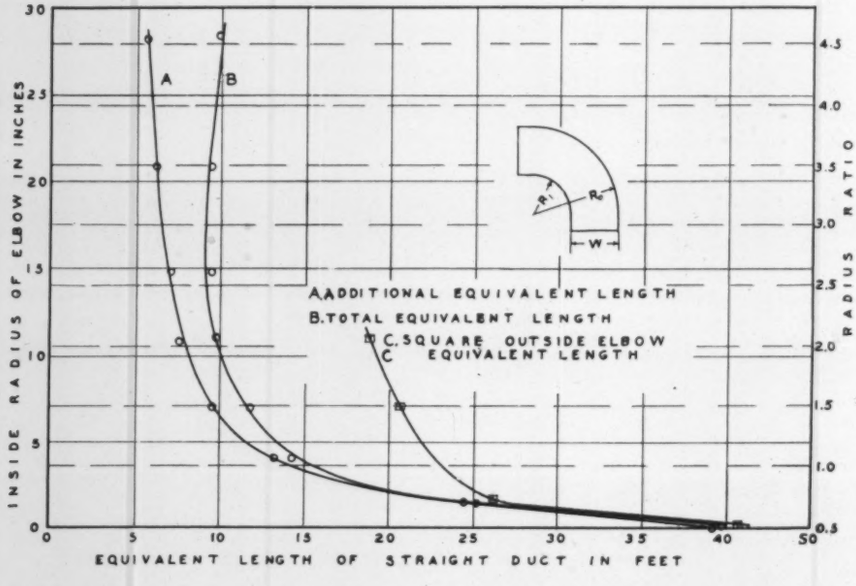

Fig. 2—Relation between inside radius of elbows and equivalent length of straight duct

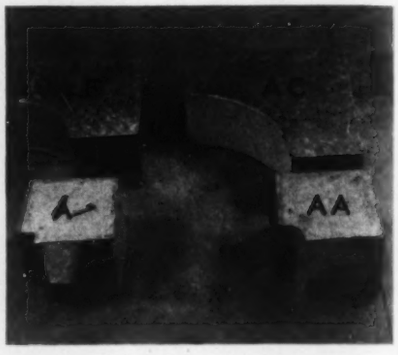

Fig. 3 — Elbows with square outside corners

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†Instructor in Mechanical Engineering, Lehigh University.
††Numbers in parentheses refer to Bibliography.
Presented at the Semi-Annual Meeting of the American Society of Heating and Ventilating Engineers, St. Paul, Minn., June, 1942.

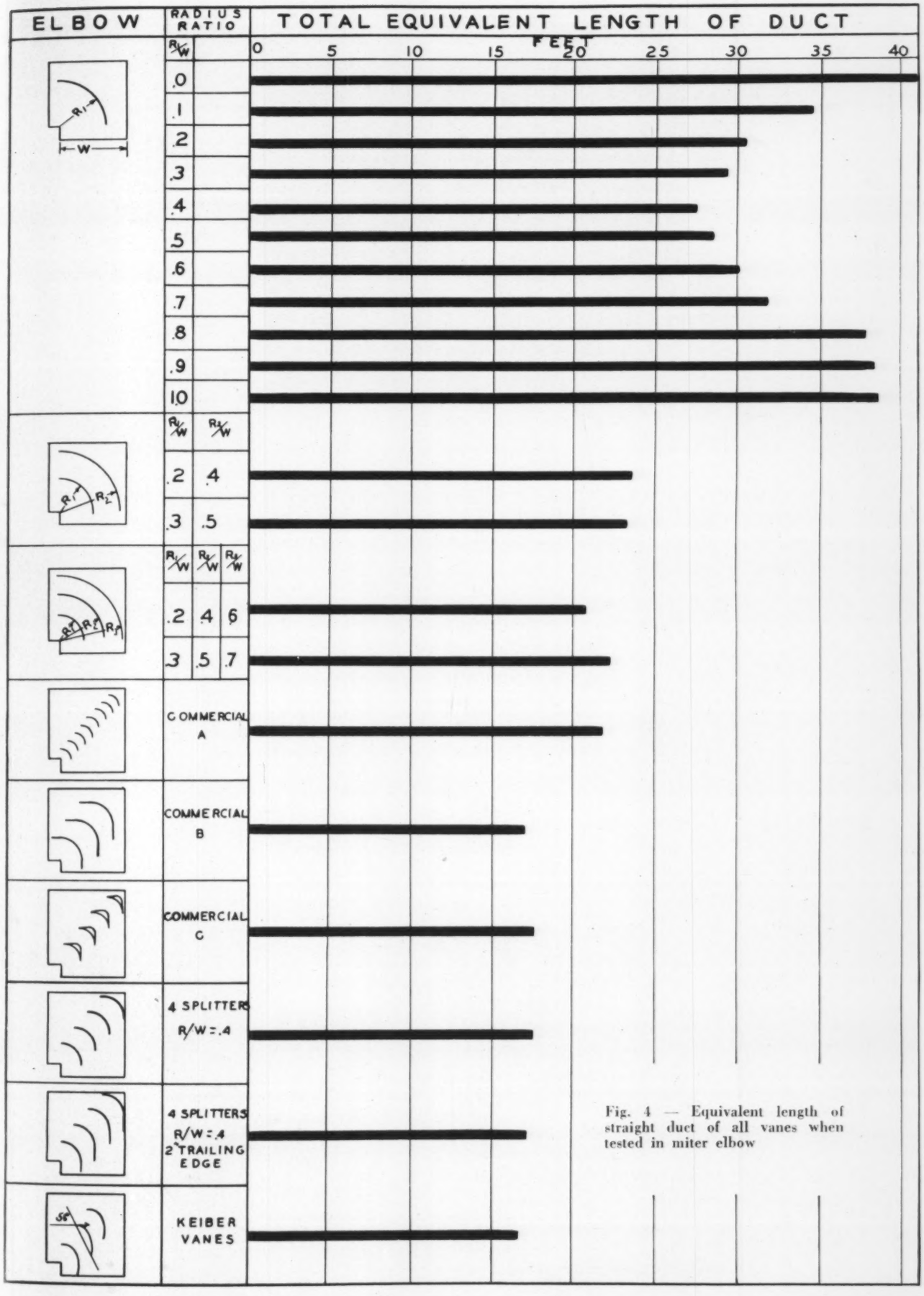

Fig. 4 — Equivalent length of straight duct of all vanes when tested in miter elbow

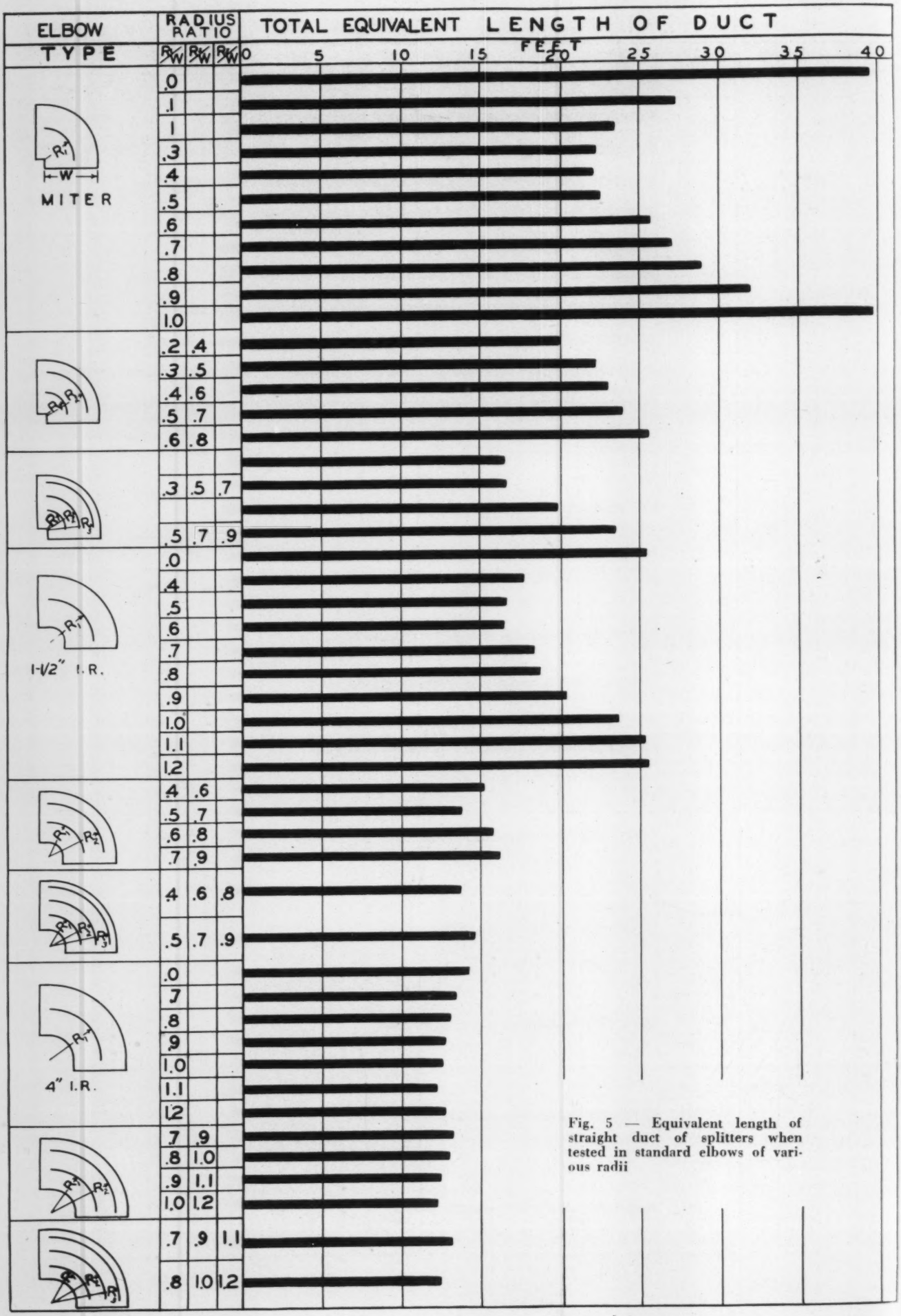

Fig. 5 — Equivalent length of straight duct of splitters when tested in standard elbows of various radii

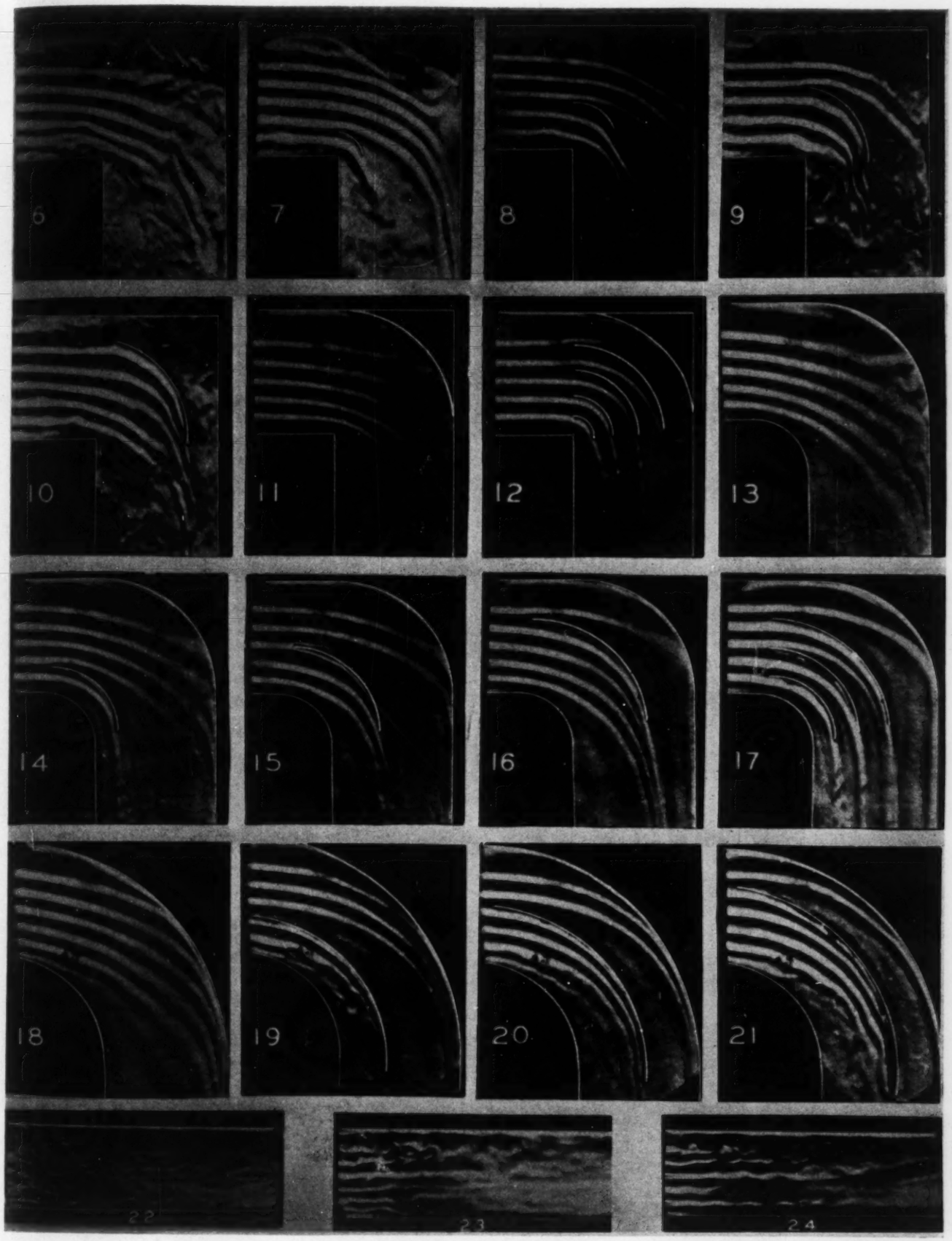

Fig. 6—Flow in miter elbow. Figs. 7-12—Flow in miter elbow with splitter. (7) *0.2 R/W*; (8) *0.4 R/W*; (9) *0.6 R/W*; (10) *0.8 R/W*; (11) *1.0 R/W*; (12) *All four splitters.* Fig. 13—Flow in 0.87 radius ratio elbow. Figs. 14-17—Flow in 0.87 radius ratio elbow with splitter. (14) *0.6 R/W*; (15) *0.8 R/W*; (16) *1.0 R/W*; (17) *All three splitters.*

Fig. 18—Flow in 1.50 radius ratio elbow. Figs. 19-21—Flow in 1.50 radius ratio elbow with splitter. (19) *1.2 R/W*; (20) *1.4 R/W*; (21) *1.6 R/W.* Fig. 22—Flow after the miter elbow. Fig. 23—Flow after the miter elbow with four 0.4 R/W splitters. Fig. 24—Flow after the miter elbow with four Keiber vanes.

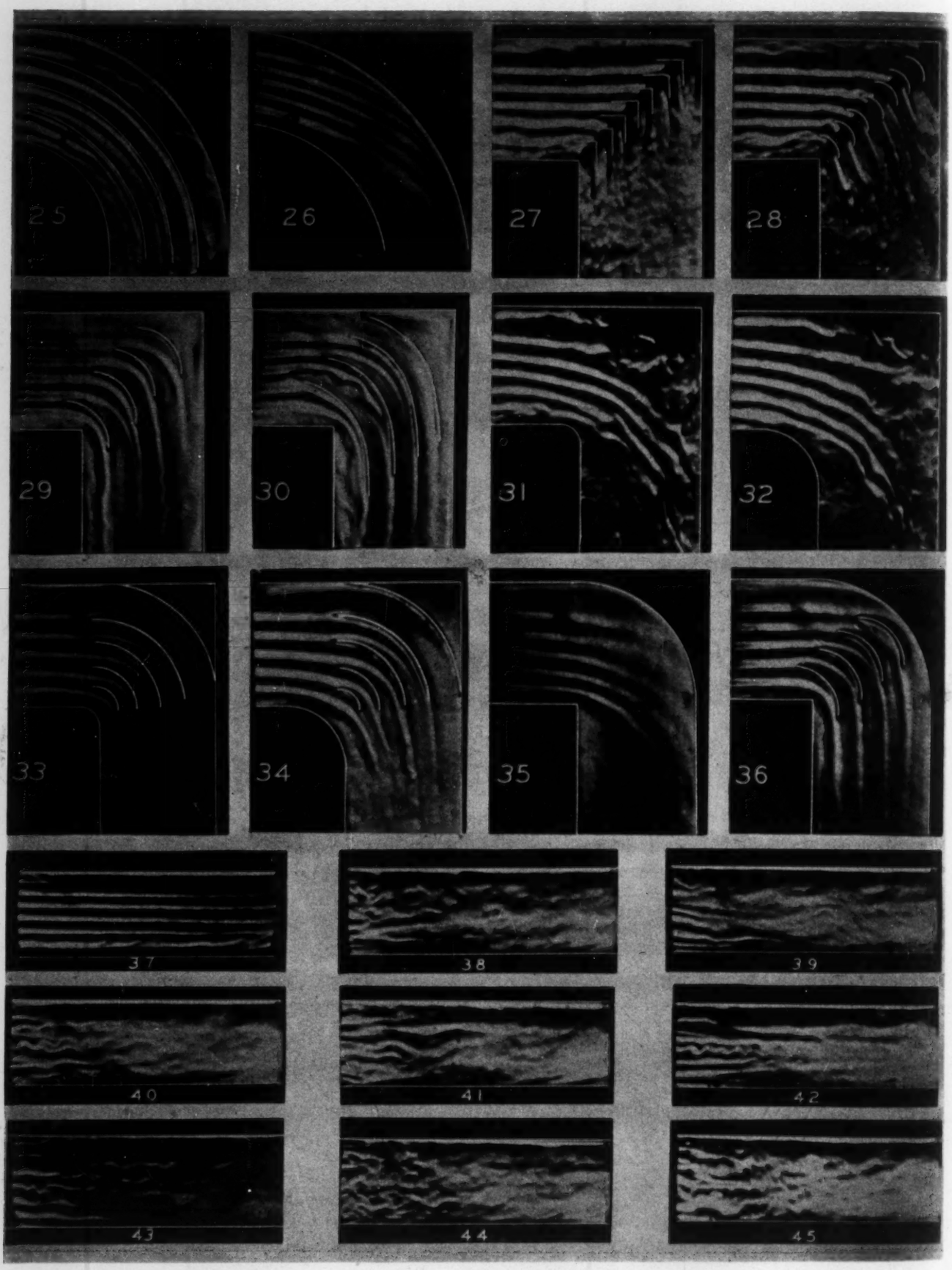

Fig. 25—Flow in 1.50 radius ratio elbow with all of splitters. Fig. 26—Flow in 2.17 radius ratio elbow. Figs. 27-30—Flow in miter elbow. (*27*) *With right angle vanes;* (*28*) *with small radius splitters;* (*29*) *with four 0.4 R/W splitters;* (*30*) *with four Keiber vanes.* Figs. 31-34—Flow in square outside elbow. (*31*) *Small inside radius;* (*32*) *medium inside radius;* (*33*) *small inside radius with splitters;* (*34*) *medium sized inside radius with splitters.*

Figs. 35-36—Flow in standard miter elbow. (*36*) *With four 0.4 R/W splitters.* Fig. 37—Flow in duct before an elbow. Fig. 38—Flow after standard miter elbow. Figs. 39-40—Flow after 0.87 radius ratio elbow. (*40*) *with one splitter in middle.* Figs. 41-42—Flow after 1.50 radius ratio elbow. (*42*) *with one splitter in middle.* Fig. 43—Flow after 2.17 radius ratio elbow. Figs. 44-45—Flow after square outside elbow. (*44*) *small radius inside.* (*45*) *medium radius inside.*

Measured pressure drop of a section of duct including an elbow minus the calculated pressure drop of a straight section of duct having the same centerline length.

The loss per foot of straight duct.

The total equivalent length is defined as the additional equivalent length plus the centerline length of elbow. (For pressure loss per foot of duct see ASHVE HEATING, VENTILATING, AIR CONDITIONING GUIDE, 1942.)

As in the case of elbows in round duct, the pressure loss, expressed in total equivalent length, was found to be independent of velocity. *Curve B* indicates that total equivalent length decreases with increased radii until a minimum value of 9.5 ft of duct is reached, whereupon any further increase in radius will cause an increase in total equivalent length. These results are also given in tabular form in Table 1.

The elbow with a radius ratio of 2.6 has the minimum loss expressed as total equivalent length. This result is substantiated by data by Kirkwood, (1), replotted by Konzo, (10).

Elbows with Square Outside Corners

In an earlier investigation by Wirt, (7) it was found that elbows with square outside corners have less loss than those with well rounded outside corners. This result which seemed surprising was upheld by data and pictures presented in the paper. However, two later investigations, one by Brown, (2), and the other by Madison and Parker, (5), presented data that showed the loss for an elbow with square corner to be larger than for one with a rounded corner. In order to throw light on this question, four elbows, with square outside corners shown in Fig. 3, were tested. All of these elbows were tested over a velocity range of 400 to 3500 fpm. The results, as shown by *Curve C*, Fig. 2, show that in all cases the square outside elbows have a greater loss than the corresponding radius elbows. The excess loss becomes much more pronounced as the inside radius increases.

Elbows in Series

In order to study the effect of elbows in an actual installation, a test system was set up using three elbows and 130 ft of straight duct arranged as follows: the fan and discharge box, 16 ft of duct, the first measuring station, 7 ft of duct, the first elbow, 25 ft of duct, the second elbow, 25 ft of duct, the third elbow, 35 ft of duct, the second measuring station, 15 ft of duct, and the plenum chamber. The straight duct between the measuring stations was 92 ft long.

Three different sets of three elbows each, contributing 56, 40, and 31 per cent of the total loss were used. Set No. 1 was made up of three 0.5 radius ratio elbows; set No. 2, three 1.1 radius ratio elbows; and set No. 3, one 0.5, one 1.1, and one 2.6 radius ratio elbow. Tests were run at velocities from 750 to 3500 fpm and in all cases, the calculated drop differed from the measured drop by only ±0.02 in. of water for the low velocities and ±0.04 in. of water for the high velocities.

Pressure Loss with Vanes and Splitters

The present investigation was directed largely to determine the action of different types of vanes and splitters in reducing pressure loss in elbows. Several previous investigators have shown agreement as to the effects of certain shapes of vanes. Brown, (2), Patterson, (8), and Kline, Tupper, and Green, (9), have presented results of separate investigations of different sizes and shapes of vanes, and all have reached the conclusion that the simple splitter bent on a moderately long radius, making 90 deg of arc, is the most practical vane. Therefore, this investigation includes only the simple splitter, the Keiber vane, and three commercial vanes.

To avoid confusion, a vane is herein defined as any curved section used to direct the air flow, while a splitter is a thin vane which includes a circular 90 deg arc.

Commercial Vanes

All vanes may be grouped into three classes: *A*—those made up of a large number of small splitters; *B*—those made up of a small number of large splitters bent on a large radius; *C*—hollow vanes having different outside and inside curvature.

Each of the three commercial vanes tested came under a different classification so that a comparison could be made. All three commercial vanes were tested in the miter square outside corner elbow and the 1½ in. inside radius square outside corner elbow. The test velocities ranged from 1200 to 3500 fpm.

The results as given by Fig. 4 and Table 1 show that vanes *B* and *C* have the lowest loss when used in each elbow. The use of these vanes in the 1½ in. inside radius elbow reduces the loss only 34 per cent.

Vane *C* was cut down by the manufacturer from a vane for larger sized duct and, consequently, restricted the flow more than would be experienced normally.

Splitters

In order to obtain information on the characteristics of various splitters and combinations of split-

Table 1 — Elbows with Round Outer Radius

Elbow Designation	Inside Radius in In.	Additional Equivalent Length in Ft	Total Equivalent Length in Ft
Standard	0	39.2	39.7
B	1½	24.6	25.3
C	4	13.2	14.2
D	7	9.5	10.9
E	11	7.7	9.6
F	15	7.1	9.5
G	21	6.4	9.6
H	28½	5.9	10.0
Square Outer Radius			
A	0	40.6	41.1
A-A	1½	22.8	23.5
A-B	7	19.4	20.8
A-C	11	16.8	18.7
Commercial Vanes			
	Vane Designation		
A	A	21.3	21.8
	B	16.47	17.02
	C	17.4	17.9
A-A	A	16.6	17.3
	B	13.7	14.4
	C	14.3	15.0

ters, the miter inside and square outside elbow, the standard miter elbow, the 1½ in. inside radius elbow, and the 4 in. inside radius elbow, were fitted with various splitters. The splitters having radius ratios of 0.2 to 1.2 were tested in one splitter, two splitter, and three splitter combinations. In all cases the center of curvature of the splitter was either the inside corner of the elbow or the center of curvature of the elbow.

The results as given by Figs. 4 and 5 show that, in each elbow and at all velocities, the single splitter reduces the loss caused by the elbow with increase in radius ratio until a minimum value is reached, then, the loss begins to increase with increased radius ratio. It will be noted that splitters either close to the inside or outside have little effect. The results, also, show that the loss of the elbow can be reduced by using 2 or 3 splitters instead of one. The effect of the splitter becomes less as the inside radius of the elbow increases. In fact, the results of the tests on the 4 in. inside radius elbow show very little reduction in loss by the use of splitters.

Because the splitter with a radius ratio of 0.4 was the best when used in a miter elbow, four of these were tested in combination and a very material reduction in loss was noted. The addition of 2 in. of trailing edge to the splitters reduced the loss a little but not enough to make their use advantageous.

In order to determine the extent to which the loss could be reduced if the best type of theoretical vane were used, three Keiber vanes, (13), were tested in the miter inside and square outside elbow. The results, Fig. 4, show that the loss is lower than that obtained by any other vane tested.

Model Study

In order to obtain a picture of the flow pattern in an elbow, a model, (see Appendix, Fig. A), was made for use in the *schlieren* apparatus. The model was made of three sections: the inlet, the elbow, and the discharge. The inlet section was fitted with a bell mouth and an egg crate straightener to establish uniform flow at the entrance to the elbow. The elbow was made by fitting different shaped outlines of wood between two ½ in. glass plates held in place by an aluminum frame. The discharge section, fitted with a slide gate to control the velocity, led from the elbow to the suction side of a constant speed fan.

While the 1 x 3-in. duct formed by the model did not accurately reproduce the secondary flow as found in the 7 x7-in. duct, it reproduced the flow in the plane of the bend to be sufficiently indicative of the true flow for practical consideration.

As the air stream entered the elbow, an electrically heated wire grid heated streams of air ½ in. apart, and these heated streams appeared as white streaks in the *schlieren* picture. (For a description of *schlieren* apparatus, see Appendix.) The *schlieren* apparatus was used for two reasons: the flow streak disappears when the turbulence becomes too great and there is no foreign element introduced into the air stream.

The elbows in the model had radius ratios of 0.5, 0.87, 1.50, and 2.17. The balsa wood splitters and vanes used, having radius ratio of 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, and 1.6 were held in place by cementing them to the glass. In the accompanying photographs the elbow walls and vanes have been outlined with white ink to make them more prominent. The slightly rough appearance of some of the vanes is due to the cement.

In Figs. 13 to 17 of the 0.87 radius ratio, it will be noted that the walls are not concentric. The inside radius is too large for the outside radius making the separation at the outside wall less than would be experienced in the correct elbow.

The result of this work is given by Figs. 6 to 45. These pictures tell the same story as the loss determination tests. Figs. 6, 13, 18, and 26 show that as the inside radius is increased, the flow becomes smoother and less turbulent. They also indicate that the shape of the inside corner greatly affects the pressure loss. Figs. 31 and 32 show that the square outside elbow does cause much turbulence which disproves the contention of Wi (7). Fig. 35 shows the way in which the turbulence is reduced by rounding the outside of a mit elbow. Figs. 7, 8, 9, 10, and 12 show how each splitter bends the flow into a smooth path until, when all five splitters are used, the air leaves in almost as smooth a flow as when it enters. Figs. 19, 20, 21, and 25 show how little the splitters affect the flow of a large radius elbow. The best flow patterns for the miter elbow are given by Figs. 29 and 30 using the four 0.4 radius ratio splitters and the Keiber vanes.

Figs. 22, 23, 24, and 38 to 45 give a picture of what takes place after the various elbows with and without splitters. These views were taken at a point 2 in. after the elbows. Fig. 37 shows the flow before the elbow and should be used as a standard of excellence. Figs. 23 and 24 show to what extent the flow can be smoothed out by the use of proper vanes in a miter elbow over that of Fig. 22 without any vanes. Fig. 43 of the flow after a large radius elbow shows how little a good elbow disturbs the air flow.

Conclusions and Results

From this investigation several significant conclusions may be drawn:

1. The loss caused by an elbow may be reduced by increasing the radius until a minimum value is reached by an elbow having a radius ratio of 2.6.
2. Elbows with square outside walls cause larger losses than do elbows of curved outside walls.
3. Splitters very materially reduce the loss of miter elbows.
4. The simple 90 deg arc splitter has almost as much effect on the reduction of the loss as do the more complicated vanes.
5. An *easy* elbow has less loss than the miter equipped with the best vanes.
6. Equivalent lengths of pipe for the different elbows are presented in Table 1.

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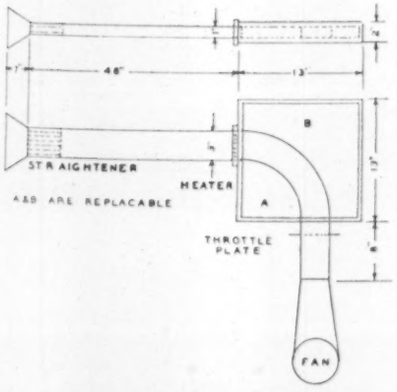

Fig. A—**Elbow model used in *schlieren* apparatus**

Appendix

The *schlieren* apparatus has been used in the study of flow phenomena by many experimenters. In recent years it has been used most extensively at the National Physics Laboratory in England. While basic arrangement of the apparatus need not be changed, by changing the design of the cut-off or stop and small mirror, many varied effects can be produced which are best suited for a particular type of investigation. A diagram of the model used in this investigation is shown in Fig. A.

The arrangement of the basic apparatus is shown in part *A* of Fig. B. Light from a high intensity source *L* is focused by a condensing lens on the small mirror, M_1, located at the center of curvature of a large spherical mirror, M_2. The light then goes to the large mirror and is reflected back to the cut-off *S* just slightly offset from M_1. A viewing screen *P* is placed after the cut-off.

If an object with an index of refraction differing from that of air is placed between M_2 and *S*, as shown in part *B* of Fig. B, some light rays will be bent so that they will go past the cut-off and form an image on the screen. Therefore, if streams of heated air are passed through the field of view, an image will appear on the screen and will give a picture similar to smoke streams. The unheated air in the stream will not affect the light so that the field will be dark but the heated air will cause light streaks.

Different methods of heating the air have been used by investigators, depending upon the effect desired. If sparks are used whose interval is known, the image appears as dots in stream lines and the spacing indicates the velocity. When hot wires are used, a steady stream image is produced so that actual flow patterns may be studied.

The light source used was a 50 cp. automobile head light bulb made to operate on 6 volts but operated on 10 volts to give more light. The light was focused on a metal diaphragm with a $\frac{1}{64}$ hole by an achromatic condensing lens. This produced the effect of having a real light source $\frac{1}{64}$ in. diameter located

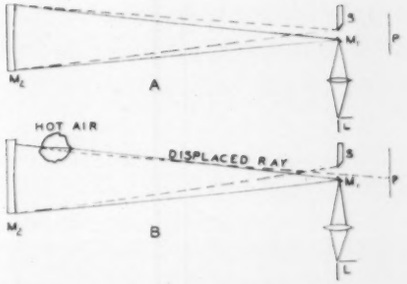

Fig. B — Schematic drawing of *schlieren* apparatus

at the focal point of the large mirror. The small mirror was made of optically flat glass surfaced on the front. The large spherical mirror ground on a 12-ft radius was 12 in. in diameter.

The cut-off must be arranged according to the direction of flow because the heated air stream has the effect of bending the light in only one direction. Since, in this investigation, the flow turned through 90 deg the cut-off used was in the shape of an L with the sides making an angle of 90 deg with the two directions of flow in the model.

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CORROSION IN STEAM PIPES

Dr. J. C. Warner, head of the Department of Chemistry at Carnegie Institute of Technology, Pittsburgh, Pa., and F. C. McIntosh, Chairman of the Committee on Research of the ASHVE, announce the consummation of a cooperative agreement to investigate one of the causes of rust in steam pipes and equipment. The particular phase of the problem to be studied is the process by which carbon dioxide, entering with the steam, becomes dissolved in the condensate.

The research work will be carried on in the Institute's Chemical Laboratory in an apparatus especially designed to represent types of equipment in actual service.

Simultaneous Heat and Vapor Transfer Characteristics of an Insulating Material

By F. G. Hechler,* E. R. McLaughlin,** and E. R. Queer,† State College, Pa.

SUMMARY — The paper discusses the two major forces which influence the transfer of vapor through building insulations. The two types of moisture movement are described and the results of investigations and the operation of the test equipment used for determining moisture and vapor conditions are outlined. It was demonstrated that moisture can collect in or be driven from specimens under test and the conductivity is not appreciably affected by the first 7 per cent moisture.

THE PRIMARY purpose of a building insulating material is to restrict the flow of heat from one space to another. Any action which tends to thwart this purpose may be a vital consideration. Free moisture within a material nearly always decreases its thermal resistance and hence the water vapor transfer characteristics of the material are of interest.

There are two major forces which tend to transfer vapor through building insulation. The first of these which affects all materials is the differential that exists between the vapor pressure on opposite sides of the insulation. This pressure differential causes a net diffusion of vapor in a manner postulated as Ficks Law, which in the integrated mathematical form is:

$$W = D\,A\,t\,\frac{dP}{dx}$$

This states that for a given area A the weight of vapor W which diffuses through the material is proportional to the time t and the vapor pressure gradient $\frac{dP}{dx}$.

Organic materials also transfer moisture due to another force known as hygroscopic action. These materials assume a moisture content which is proportional to the relative humidity of the air. This absorbed moisture tends to migrate from spaces of higher to spaces of lower moisture concentration, and the effect is to transfer vapor from a space of higher to a space of lower relative humidity.

These two forces may operate in the same direction or they may be opposed and the vapor transferred through a material is the net result of the two forces acting simultaneously. The moisture content of the material is also the net result of the two types of moisture movement.

Test equipment which provides for these dynamic conditions has been constructed as a guarded hot box with facilities for determining the moisture and vapor conditions. A cutaway view of the box and the test room is shown in Fig. 1. The specimen S is clamped to the guard box to form the sixth side (top, in sketch) of both the test box and the guard box. The small test box inside, 18 x 18 x 15 in., fits snugly against the specimen so that it is sealed to both air and moisture along the edges by means of a rubber gasket. The inner surfaces of this box are one copper sheet shaped to form. The same is true for the outside surfaces. These copper sheets are thermally and electrically insulated from one another. The larger outside box supports this small test box and provides a 4-in. guard space around five sides of it. The inside surface of the guard box is lined with copper to provide a moisture seal. All copper surfaces are painted with shellac and lampblack. The guard box is built of cork insulation and ⅜-in. plywood braced with angle iron. The entire box is mounted so that it may be rotated to give the specimen any angular position with the horizontal, heat flowing up or down through the specimen. The entire box and its mounting is housed in a small room in which the temperature is controlled by means of a thermostat, shown in the foreground of Fig. 1. Heat is supplied by the lampbank along the left wall and all heaters are shielded so that they do not radiate directly onto the specimen or any of the thermocouples. Vents in the top and walls of the test room allow cold air to circulate through the small room from a larger cold room maintained at 0 F.

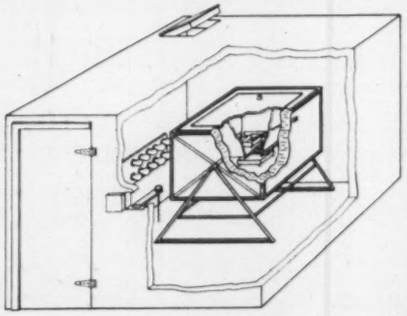

Fig. 1—Cutaway view of guarded hot box

The power circuit for the entire set-up is shown in Fig. 2. The heaters in the test box are connected in series with a watt-hour meter W and a group of switches so that any heater may be put into either continuous or intermittent service under the control of the thermostat. The relay in this circuit is actuated by the amplifier[1] in response to a photo electric tube. This gives continuous automatic air temperature control. A similar circuit maintains the air in the guard space at the same temperature.

The temperatures of the surfaces of the test specimen and of the air on both sides of it were taken by means of No. 30 A.W.G. copper-advance thermocouples and a high precision potentiometer.

Constant and equal relative humidities were maintained in the main test box and guard space by means of pans containing saturated salt solutions. For tests 5 and 6 in Table 1 a saturated solution of magnesium chloride was used. Sodium chloride

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[1]Application of Conventional Vacuum Tubes in Unconventional Circuits, by F. H. Shepard, Jr. (*Proceedings of the Institute of Radio Engineers*, 24: 1574, December, 1936.)

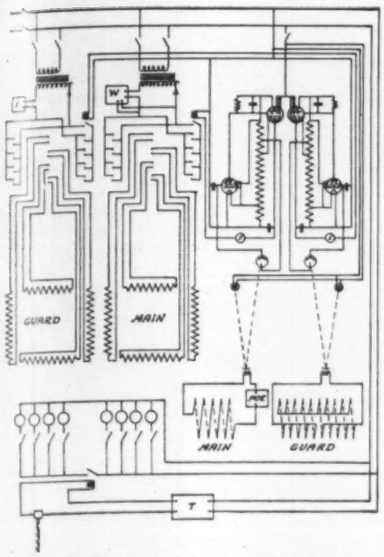

Fig. 2—Power and control circuits

solution was used for tests 7, 8, and 9; and distilled water was used for tests 10 to 13, inclusive. The relative humidity in the main box was checked by means of a small humidity and temperature recorder. Wet- and dry-bulb thermocouples indicated the relative humidity of the air in the test room.

The sample to be tested was cut to size, 28 x 28 in., and placed in a dryer at 130 F until it attained a constant weight, which was used as the base for determining moisture content.

Readings of thermocouple emf, heater voltages, and watt hour indications were taken every half hour during normal working hours. This gave consistent temperature and power readings which were averaged for the calculations.

In the dry tests, 1, 2, 3, and 4 of Table 1, there was no vapor transfer from one side of the specimen to the other and the calculations merely involved using the average rate of heat transfer per square foot of test area and the temperature differences across the air films and the specimen to determine the surface coefficients, transmittance, and conductivity. These tests afford an excellent check on the reliability of the apparatus and thermocouples. In each case the calculated conductivity checked within plus or minus one per cent of the results obtained on a similar sample tested in the 12-in. square guarded hot plates. In one case two 12-in. squares were cut from the sample tested in the guarded hot box. The hot-plate test gave a conductivity of 0.379 Btu per inch per (square foot) (hour) (degree) at a mean temperature of 65.0 F; the curve in Fig. 3 gives a value of 0.380 at the same mean temperature.

During the tests in which there was a transfer of vapor the specimen and the main pan of solution were each weighed at intervals of 24 hours or multiples thereof. As far as could be determined opening the box had no effect on the rate of vapor transfer. After the specimen acquired a constant weight all losses in weight from the pan represented moisture transmitted through the sample. In the calculations for these tests it was necessary to correct the total heat transfer for the heat transferred by the water vapor itself. This correction included the heat of vaporization and the heat loss from the vapor as it passed from a warmer to a colder space. The Keenan and Keyes steam tables were used throughout the computations. Where evaporation takes place from a saturated salt solution a correction should be made for the heat of dilution. However, calculations using data from Bichowsky and Rossini and the Handbook of Chemistry and Physics indicate that the magnitude of the heat of dilution for the highest vapor rate reported here was 0.04 Btu per (square foot) (hour) in a total transfer of 23.59 Btu per (square foot) (hour) or 0.17 per cent which is less than the accuracy of the other measurements.

The method of calculation employed may be illustrated by presenting the actual calculations for test number 12 in Table 1:

Watt-hour meter reading at 4:00 p.m. 733.40
Watt-hour meter reading at 8:00 a.m. 533.40

$$\frac{200.00}{8} = 25.00 \text{ (per hour)} \qquad 200.00$$

25.00 × 0.994 (constant for meter and conversion of units) = 24.85 Btu per (square foot) (hour)

Vapor transferred was
0.319 pounds in 24 hours, or
0.0133 lb per hour, or
992.4 grains per (square foot) (day)

Internal energy of liquid,
u_f, at 110 F = 77.9 Btu per lb

Enthalpy of vapor,
h_g, at 49.5 F = 1083.5 Btu per lb
h = 1005.6 Btu per lb

$$\text{Test area} = \frac{18 \times 18}{144} = 2.25 \text{ sq ft}$$

$$\frac{0.0133 \times 1005.6}{2.25} = 5.94 \text{ Btu per (square foot) (hour)}$$

Heat transferred through the specimen due to temperature difference is 24.85 — 5.94 = 18.91 Btu per (square foot) (hour)

$$\text{Warm side surface coefficient} = \frac{18.91}{110.0 - 100.8}$$

= 2.06 Btu per (square foot) (hour) (degree)

$$\text{Cold side surface coefficient} = \frac{18.91}{61.6 - 49.5}$$

Table 1—Steady State Tests—Horizontal Heat Flowing Upward
(0.795 in. Fibre board, 17 lb/cubic feet)

Number of Test	1	2	3	4	5	6	7	8	9	10	11	12	13
Mean Temperature, Air to Air, Fahrenheit	39.7	59.2	63.0	77.1	58.5	81.5	40.6	58.8	79.6	39.4	59.5	79.8	60.0
Temperature, Hot Air, Fahrenheit	70.3	92.4	106.0	109.0	89.2	109.1	71.0	89.0	109.2	72.3	90.0	110.0	109.6
Temperature, Hot Surface, Fahrenheit	61.6	82.0	93.4	99.4	79.8	100.8	61.2	79.3	100.1	61.9	80.3	100.8	94.6
Temperature, Cold Surface, Fahrenheit	21.9	38.9	36.5	58.0	40.0	64.8	23.3	41.3	62.0	22.2	42.0	61.6	34.1
Temperature, Cold Air, Fahrenheit	9.1	25.9	19.9	45.1	27.8	53.8	10.1	28.6	49.9	6.5	29.0	49.5	10.3
Heat Transfer, Total, Btu per sq ft (hr)	18.37	20.61	27.23	20.44	20.57	20.38	19.40	21.25	23.59	20.62	21.87	24.85	36.62
Heat Transfer, Vapor, Btu per sq ft (hr)	0.00	0.00	0.00	0.00	1.79	3.27	1.80	3.20	4.92	2.18	3.61	5.94	6.13
Heat Transfer, Thermal, Btu per sq ft (hr)	18.37	20.61	27.23	20.44	18.78	17.11	17.60	18.05	18.67	18.44	18.26	18.91	30.49
Hot Surface Coefficient, Btu per sq ft (hr) (deg)	2.11	1.98	2.16	2.13	2.00	2.06	1.80	1.86	2.05	1.77	1.88	2.06	2.03
Cold Surface Coefficient, Btu per sq ft (hr) (deg)	1.44	1.58	1.63	1.58	1.54	1.56	1.33	1.42	1.54	1.17	1.40	1.56	1.28
Transmittance, Btu per sq ft (hr) (deg)	0.300	0.310	0.316	0.320	0.305	0.309	0.289	0.299	0.315	0.280	0.299	0.313	0.307
Conductance, Btu per sq ft (hr) (deg)	0.463	0.478	0.478	0.494	0.472	0.475	0.464	0.475	0.490	0.464	0.477	0.482	0.504
Conductivity, (Btu) (in.) per (sq ft) (hr) (deg)	0.368	0.380	0.380	0.393	0.375	0.378	0.369	0.378	0.390	0.369	0.379	0.383	0.401
Mean Temperature, Surface to Surface, Fahrenheit	41.8	60.5	65.0	78.7	58.5	82.8	42.3	60.3	81.1	42.1	61.2	81.2	64.4
Moisture Content, Per Cent by weight	2.12	1.79	1.79	1.79	3.75	1.95	5.86	5.21	4.23	7.33	6.18	4.89	12.0
Relative Humidity, Hot Air, Per Cent					32.0	34.0	58.0	54.5	47.0	63.0	57.0	52.0	52.0
Vapor Pressure, Hot Side, mmHg					11.23	21.84	11.27	19.08	30.28	12.79	20.58	34.29	34.28
Relative Humidity, Cold Air, Per Cent					25.6	17.0	22.0	25.5	13.5	49.0	25.2	15.5	21.6
Vapor Pressure, Cold Side, mmHg					0.99	1.80	0.39	1.02	1.24	0.77	1.02	1.40	0.40
Vapor Pressure Difference, mmHg					10.24	20.04	10.88	18.06	29.04	12.02	19.56	32.89	33.88
Vapor Transfer, Grains per sq ft (day)					295.7	544.3	295.7	527.5	821.5	357.8	599.8	992.4	1041.7
Permeability, Grains per sq ft (day) (mmHg)					28.89	27.16	27.18	29.21	28.29	29.77	30.66	30.17	30.75

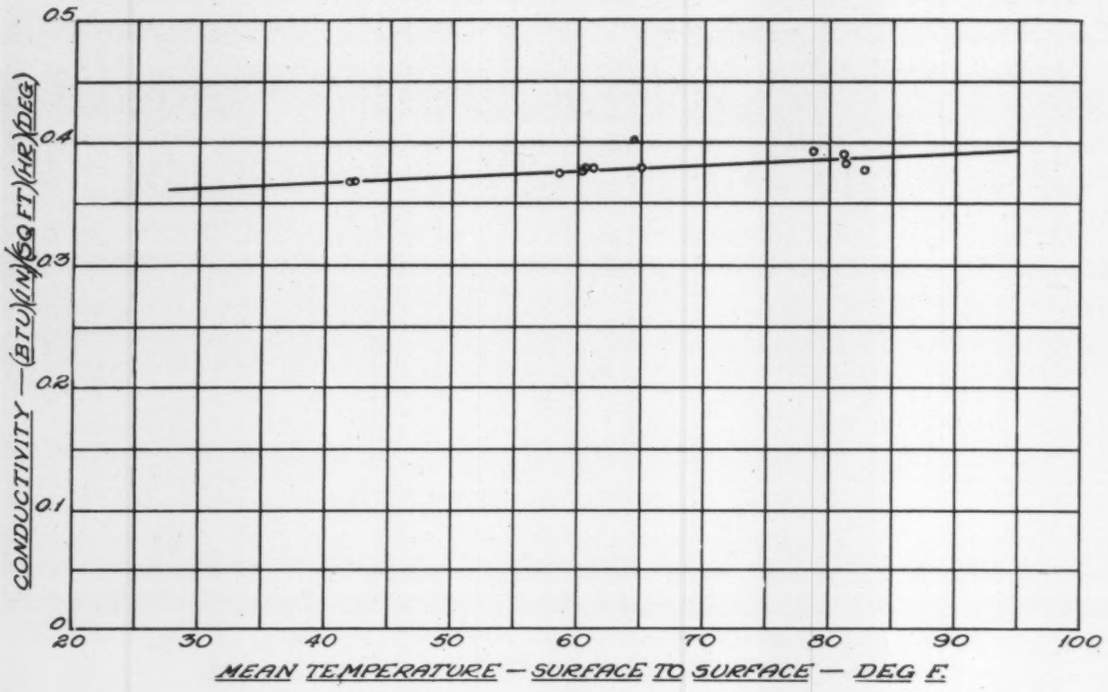

Fig. 3—Relationship of conductivity to mean temperature for 0.795-in. wood fibre board

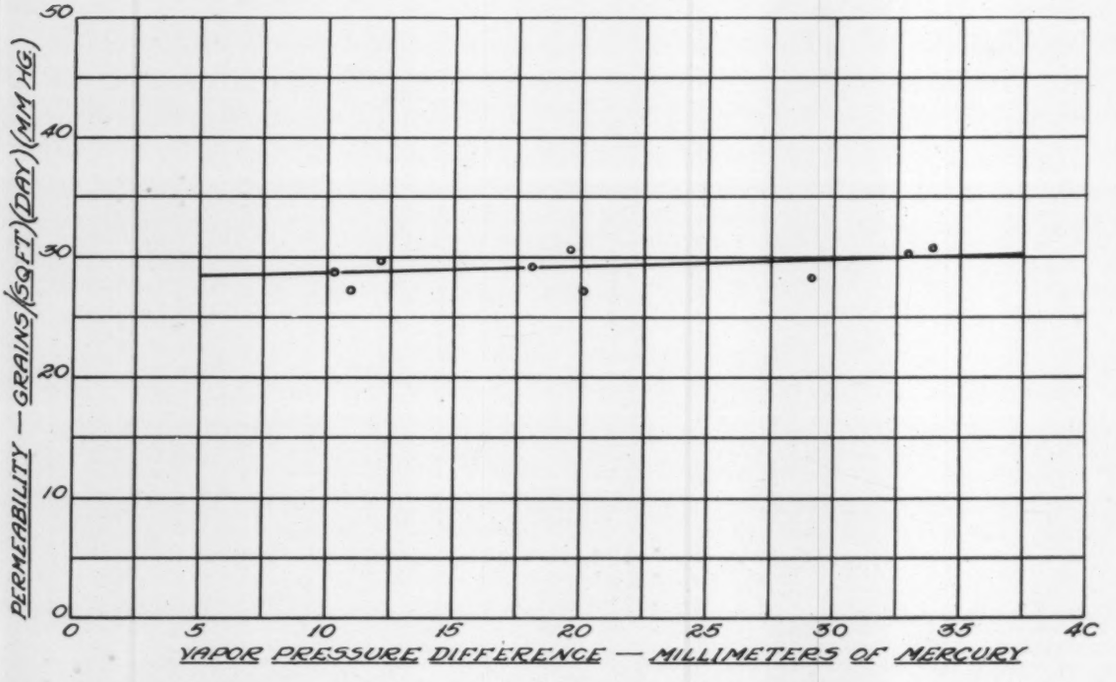

Fig. 4—Relationship of permeability to vapor pressure difference for 0.795-in. wood fibre board

$= 1.56$ Btu per (square foot) (hour) (degree)

$$\text{Transmittance} = \frac{18.91}{110.0 - 49.5} =$$

0.313 Btu per (square foot) (hour) (degree)

$$\text{Conductance} = \frac{18.91}{100.8 - 61.6} =$$

0.482 Btu per (square foot) (hour) (degree)

$$\text{Conductivity} = 0.482 \times 0.795$$

$= 0.383$ Btu (inches) per (square foot) (hour) (degree)

Vapor pressure difference $= 34.29 - 1.40 = 32.89$ mmHg

$$\text{Permeability} = \frac{992.4}{32.89} = 30.17$$ Grains per (square foot) (day) (mmHg)

The variation of conductivity with mean temperature is shown in Fig. 3 and the permeability values are plotted against vapor pressure difference in Fig. 4.

All of the tests in Table 1 were made when the specimen was in dynamic balance with the thermal

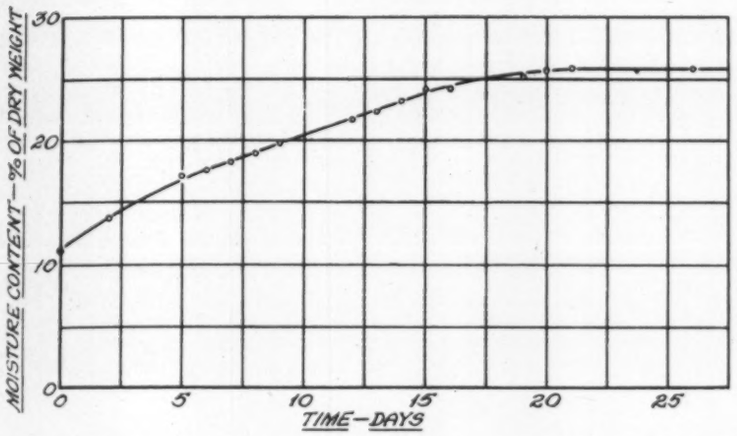

Fig. 5—Showing moisture absorbed by 0.795-in. wood fibre board subjected to constant humidity conditions

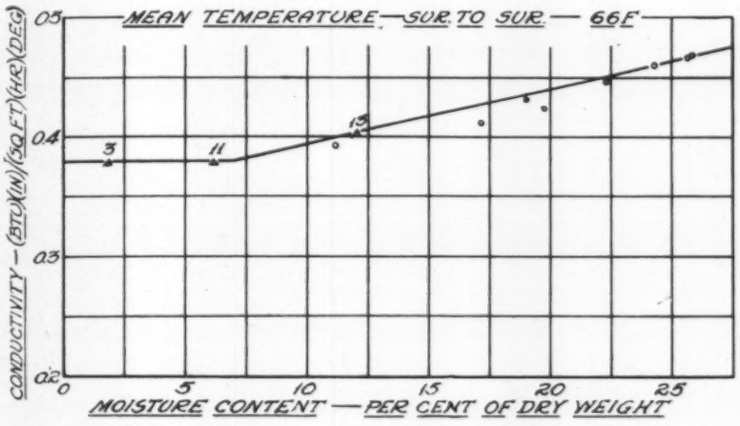

Fig. 6—Variation of thermal conductivity with moisture content for 0.795-in. wood fibre board

and vapor conditions around it. The vapor flow into the specimen equaled the flow outward. The action of the material when it is dynamically unbalanced with conditions surrounding it may also be of interest. Moisture can collect in or be driven from the specimen. Tests simulating these conditions were made by subjecting a sample containing 11 per cent moisture to air conditions of 109.0 F and 55 per cent relative humidity on the warm side and 13.5 F and 15 per cent relative humidity on the cold side. The sample gained in moisture content as shown in Table 2 and Fig. 5. The average mean temperature of the specimen during this test period was 66.0 F. Fig. 6 summarizes the data for this specimen at a mean temperature of approximately 66 F. The *balanced* points and tests 3, 11, and 13 clearly indicate that the conductivity is not appreciably affected by the first seven per cent moisture. It is known that the first moisture taken on by a material is adsorbed, a layer of one molecule in thickness covering the surfaces of the fibres. This film does not behave as a free liquid and hence probably has very little effect on the thermal conductivity of the specimen. Test conditions were such that absorbed moisture, or free liquid, did not accumulate in an amount sufficient to affect the conductivity until the 7 per cent point was

Table 2—Moisture Gain of Sample

Days	Per Cent Moisture	Conductivity	Hot Surface Coefficient	Cold Surface Coefficient	Permeability
0	11.1	0.393	1.93	1.18	.....
2	13.7	.....	.....	.....	.....
5	17.1	0.411	1.89	1.20	.....
6	17.6	.....	.....	.....	.....
7	18.4	.....	.....	.....	.....
8	19.0	0.431	1.93	1.19	.....
9	19.8	0.424	1.92	1.16	.....
12	21.7	.....	.....	.....	.....
13	22.3	0.447	1.92	1.25	.....
14	23.2	.....	.....	.....	.....
15	24.2	0.460	2.00	1.24	.....
16	24.2	.....	.....	.....	.....
19	25.1	.....	.....	.....	.....
20	25.6	0.466	1.93	1.20	.....
21	25.8	0.468	1.94	1.21	.....
26	25.8	0.469	1.88	1.25	34.21

Table 3—Moisture Loss of Specimen

Days	Per Cent Moisture	Conductivity	Surface Coefficients	
			Hot	Cold
0	25.8	0.469	1.88	1.25
1	17.6	.....	.....	.....
2	14.7	.....	.....	.....
5	11.1	.....	.....	.....
6	10.5	.....	.....	.....
7	9.9	0.409	.....	1.28
8	9.4	.....	.....	.....
9	9.0	.....	.....	.....
12	8.5	.....	.....	.....
13	8.2	0.385	.....	1.23
19	7.7	0.378	.....	1.34
21	7.5	0.373	.....	1.22

reached. The *unbalanced* points calculated for the specimen absorbing moisture were expected to be low, since the condensing moisture gives up its latent heat of condensation.

To study the procedure in the reverse direction a piece of ¼ in. plywood, 28 x 28 in., was placed on the warm side of the specimen to act as a vapor barrier. Air temperatures and humidities were held at the same values as before. This caused the specimen to lose moisture, Table 3 and Fig. 7, and since the plywood had some thermal resistance the mean temperature of the specimen was reduced to 57 F. During this

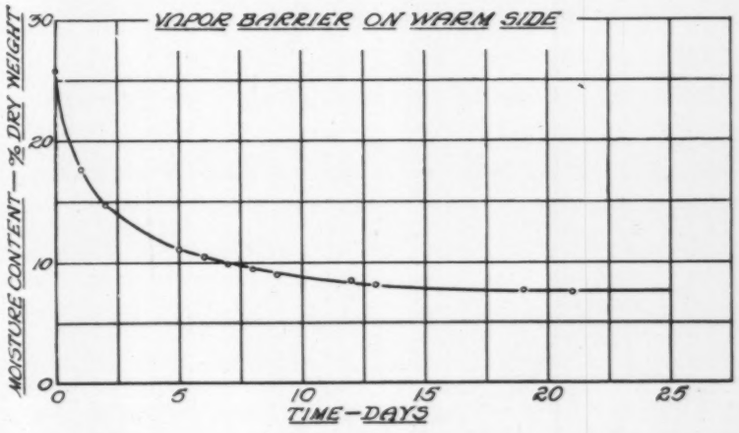

Fig. 7—Showing loss of moisture by 0.795-in. wood fibre board subjected to constant humidity conditions

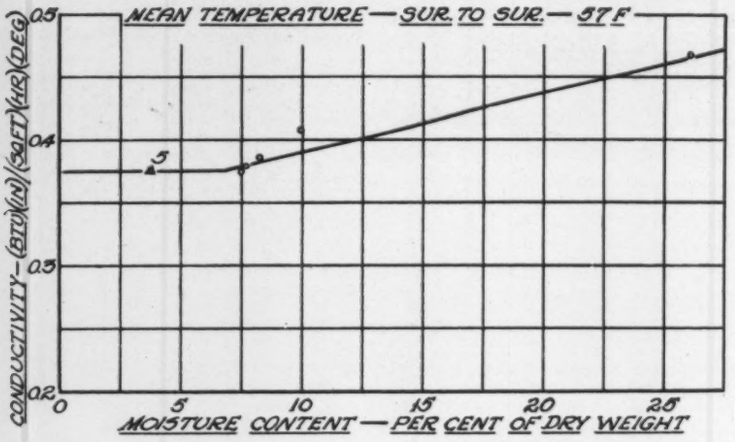

Fig. 8—Variation of thermal conductivity with moisture content for 0.795-in. wood fibre board

test the evaporation of the moisture in the sample required heat and consequently the conductivities calculated for the material in the unbalanced state are higher than the actual value. This is shown in Fig. 8 where the curve was drawn by means of the slope of Fig. 6 and the conductivity value at 57 F mean temperature from Fig. 3. The value from test 5 is also plotted here since it helps to define the curve.

The surface coefficients are given in Tables 1, 2, and 3 to show their magnitude and to indicate that they are sensitive to slight changes in surface air circulation since the temperature differences across the air films are relatively small.

The use of the test equipment is not limited to testing individual homogeneous materials, but can be used for any material or combination of materials if a representative sample can be made to fit the effective test area of the box.

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4. *Handbook of Chemistry and Physics,* 24th Edition, Chemical Rubber Publishing Co., Cleveland, 1940.)

5. *Thermodynamic Properties of Steam,* by J. H. Keenan, and F. G. Keyes, John Wiley and Sons, New York, 1936.)

6. Moisture Migration, by P. F. McDermott, (*Refrigerating Engineering,* August, 1941.)

7. Effect of Moisture on the Heat Transmission in Insulating Materials, by L. F. Miller, (*Refrigerating Engineering,* 14: November, 1927.)

8. Theory Covering the Transfer of Vapor Through Materials, by F. B. Rowley, (ASHVE Transactions, Vol. 45, 1939.)

DISCUSSION

J. D. Babbitt, Ottawa, Canada: I have read the paper with great interest. The authors' idea of measuring the heat transfer and the moisture migration through a material simultaneously is ingenious and their apparatus should lend itself to the investigation of many doubtful points in the theory of moisture migration. The results which they give indicate that the apparatus is capable of considerable accuracy with regard to both thermal and moisture measurements. It is probably the first time that accurate measurements have been made on the influence of moisture transfer on thermal conductance.

I notice with interest that the permeability as given in the last line of Table 1, or in Fig. 4, shows a very small change with mean relative humidity or with vapor pressure difference so that for all practical purposes the vapor transfer can be assumed as proportional to the vapor pressure difference. This lends further support to the assumption that a theory of moisture movement developed on the basis of Fick's Law can be used to evaluate the migration of vapor in any structure if the vapor pressures and the permeabilities of the materials are known. We are thus entitled to use the values of the permeabilities obtained from vapometer measurements for such calculations.

In this respect it is necessary to state that, because of its simplicity and reproducibility, the vapometer test still seems to be the best for evaluating and for comparing the permeabilities of different materials. It is the counterpart of the hot-plate apparatus in thermal transmission work. It is in testing the application of permeability coefficients to actual practic that an apparatus such as that used b the authors can be of great value. Fo instance, an apparatus of this natur could be used to determine if there ar any conditions which might arise in prac tice where Fick's Law would not hol At present this seems doubtful.

Another useful purpose for which suc an apparatus could be used would be t determine the conditions under whic condensation would occur within a struc ture. A series of experiments of thi nature would give a firm basis on whic to set a minimum standard for the per meability of vapor barriers. Finally this apparatus might be adapted to obtain some data on the effect of cracks on the efficiency of vapor barriers—a subject in which we are still at the guessing stage.

E. C. Lloyd, Lancaster, Pa.: The conductivity of insulating material when vapor is present has been for years a moot point with those dealing with the properties of materials used particularly at temperatures below normal. This paper represents an excellent start in the direction of a consideration of the influence of contained moisture passage on the thermal conductivity, and it is to be hoped that additional work will be done which will throw even more light on the subject than is done in this very excellent paper.

Certainly the authors are to be congratulated on the start they have made thus far, and we hope that at a later date we may hear from them with additional information gained in the test equipment developed at the Engineering Experiment Station at the Pennsylvania State College.

L. V. Teesdale, Forest Products Laboratory, Madison, Wis.: I am pleased to see this paper and wish I could spare the time to study it carefully at this time, but we are engaged in national defense work and do not have the time to spare on other types of research. The apparatus used seems to be suitable for a variety of tests that should yield new information of real value to those interested in the subject of vapor and heat movement through materials.

Though I have not digested the paper carefully, there are a few points that I would like to discuss briefly. Fig. 4 indicates that vapor movement is proportional to vapor pressure differences. In our studies this principle seems to hold for materials of rather low vapor resistance but not in the case of high vapor resistance. In the latter type the vapor transmission values were not reduced proportionate to reduced vapor pressure differences.

It may be true that on account of the low density of the fiber board its conductivity is not appreciably affected by the first 7 per cent of moisture. In the case

of wood having a density of 0.5 at 7 per cent moisture content the calculated conductivity is 10 per cent greater than at 0 per cent moisture content.

JOHN JAMES, New York, N. Y.: In addition to the two major forces of vapor transfer transmitted through building insulation cited by the authors, is the migration of moisture through porous material due to the influence of convection currents. It is fortunate that the apparatus has been designed so that the box can be rotated through any angular position with the horizontal, as it is probable that varying results of moisture travel will be observed with porous specimens located in a vertical position as contrasted with the horizontal when the heat and moisture flow is from the inside of the box to the outside.

BENJAMIN FRANKLIN, PATRON SAINT OF HEATING

The twentieth century, so far as living conditions go, is by far the most comfortable era of all time. A hundred and fifty to two hundred years ago, stuffy rooms with warmth only in front of the fireplaces, cold draughts seeping in at the edges, with ventilation that was inadequate and unhealthy, and with heating that was dangerous, were the rule. It was Benjamin Franklin, jack of all trades and master of all, who took the first steps toward improving these conditions.

By making life safer and more comfortable for his contemporaries, Franklin laid the foundation for the elaborate systems of heating, air circulation, and humidifying of air that are familiar today.

A uniformly warm room was unknown in Franklin's time. When very cold, people were obliged to huddle around the fireplace, where part of them was half scorched, while the other part remained icy. Franklin introduced warm rooms with his invention of the cast iron stove which had an arrangement of draughts for a more even distribution of heat. Eighteenth century eyes smarted from smoke that poured into rooms, while the heat escaped up the chimney. Franklin invented a form of fireplace damper which permitted a more comfortable distribution of heat and eliminated smoke. To decrease the fire hazard from the roaring blazes in the large, open fireplaces, he made a study of chimneys and thought out their proper construction.

These advances of Franklin still endure, though sometimes in more developed forms.

Present warm-air heating systems derive from his original invention of the Pennsylvanian Fireplace (or Franklin Stove),[1] in which the heat from an open fireplace, after ascending, was made to descend before escaping through the chimney, thus heating currents of fresh air as they entered the room. Modern fireproof chimneys are based on his studies and observations, described in *"On the Causes and Cure of Smoky Chimneys."* And the technique of heating large buildings was first described by Franklin in a letter which explained the movements of air currents, the best method of heating them, and planning for proper ventilation.

Franklin also evolved and described a stove which burned pit coal and consumed all its smoke in the chimney. This operated on the principle of the siphon, so that fire was made to draw downward, consuming its own smoke. It burned either coal or wood.

A life-long interest in evaporation, which proved the possibility for getting freezing temperatures in the hottest weather, began for Franklin when he noticed that sailors tested the direction of the wind by wetting a finger and then testing which side felt coolest in the breeze.

In practice, he insisted upon good ventilation, and in numerous letters and articles, ridiculed the contemporary prejudice against fresh air and pleaded for more open windows. His own home incorporated ventilation facilities far in advance of his time. There were unique heating provisions as well. In the library, for example, there was placed "below the grate on the hearth, a small iron plate or trapdoor. When this door was raised, a current of air from the cellar rushed through to rekindle the fire."

The contributions Franklin made to the field of heating and ventilation[2] are only one phase of the many services he performed for the benefit of humanity. Franklin never made any money from any of his inventions. He believed that such things should be donated to the public and refused to take out patents on them. His interest in heating and ventilation came, in addition to simple scientific curiosity, from his desire to make existence happier and more comfortable for people. The great progress in this field over the last century has been built upon his findings and has amply fulfilled his ambition to create healthy and comfortable living conditions.

Benjamin Franklin is the patron saint of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS and it is significant that the Society has carried on the tradition of fundamental research in this field so well exemplified by Franklin.

A committee has recently been formed by the Franklin Institute in Philadelphia to recall to Americans the greatness of Franklin and his continuing contributions to many fields of endeavor. This National Franklin Committee has compiled material, which is available to interested groups and details will be furnished by the committee, Benjamin Franklin Parkway at 20th Street, Philadelphia, Pa.

[1] ASHVE TRANSACTIONS, Vol. 19, 1913.
[2] The Amazing Benj. Franklin, J. Henry Smythe, Jr. (Stokes, 1929).

PHILADELPHIANS HOLD MEETING

May 14, 1942. The regular meeting of the Philadelphia Chapter was held at the Philmont Country Club, Philadelphia, and all facilities of the Club were made available to the 85 members and guests present.

After an excellent participation on the golf course, together with sound engineering in the handicap system, 33 members were eligible for awards.

Following dinner, the meeting was called to order by Pres. H. B. Hedges, and in accordance with the custom, it was moved and seconded that the reading of the minutes and the treasurer's report be dispensed with. M. F. Blankin read a resolution prepared to indicate the Chapter's sympathy for the family of the late R. C. Bolsinger and its appreciation of his service to the Chapter and Society. The assembly stood a moment in silence in honor of his memory.

President Hedges turned the meeting over to the newly elected president, H. H. Mather, with an expression of appreciation and

thanks for the cooperation of the Chapter during the year. A token of appreciation by the Board of Governors was presented to Mr. Hedges.

At the conclusion the new officers were introduced and a vote of thanks for the excellent service at the Club and the general enjoyment of the day was tendered to Mr. Sheffler.

W. P. Culbert then awarded the various golfers for their skill on the golf course, followed by adjournment at 9:45 p.m.

DELTA INSTALLS NEW OFFICERS

June 9, 1942. The regular luncheon meeting of the Delta Chapter was held at Arnaud's Restaurant, New Orleans, and 16 members and guests were in attendance. The meeting was called to order by Pres. G. C. Kerr, and the minutes of the previous meeting were dispensed with.

The installation of officers was announced by E. E. May, chairman of the nominating committee and the following were inducted into office:

President—G. C. Kerr
Vice-President—F. D. Graham
Secretary—L. V. Cressy
Treasurer—J. J. Friedler, Jr.
Board of Governors—G. E. May, A. L. Dunlap, Fritz Gutknecht.

Mr. May then reported on the work of the special blackout committee, which is studying all available data and is cooperating with the local Civilian Defense Office in covering all conceivable conditions affecting the ventilating problems during blackouts.

J. J. Friedler, Jr., spoke briefly about his experiences with priorities, which were enjoyed and appreciated by his audience, after which the meeting was adjourned.

MASSACHUSETTS MEMBERS MEET

May 19, 1942. The Massachusetts Chapter held its monthly meeting at the Massachusetts Institute of Technology and 30 members and guests attended. President Brinton called the meeting to order.

The treasurer was instructed to buy a $100.00 Defense Bond, and the meeting was turned over to W. T. Jones, who presented Frederick D. B. Ingalls with a certificate of Life Membership in the Society awarded to him at the January 1942 Council Meeting. Mr. Ingalls was also voted a Life Member in the Massachusetts Chapter.

Donald Blair was introduced as the guest of the evening and he spoke on the heating system management and cost control, which was an interesting presentation. He brought out the need for a common language to bring the operating men and managers of plants together, and showed how it could be done.

After an informal discussion Mr. Blair was given a rising vote of thanks.

The following were elected to serve the Massachusetts Chapter for the coming year:

President—E. G. Carrier
Vice-President—F. R. Ellis
Secretary-Treasurer—R. T. Kern
Board of Governors—Q. J. Ahearn, F. R. Ellis and G. B. Gerrish.

FBI REPRESENTATIVE TALKS AT NORTH CAROLINA

May 8, 1942. The North Carolina Chapter of the Society held its annual spring meeting at Thacker's Restaurant, Charlotte, and following dinner the group was addressed by Edward Scheidt, director of the Southern District office of the Federal Bureau of Investigation in Charlotte. Mr. Scheidt's talk was timely and extremely interesting, dealing with some of the methods used in counter-espionage and stressing the importance of constant alertness on the part of everyone. From his narration of the events leading to the apprehension of the Charles Sebold ring it became evident that under the FBI this country has the most effective machinery in its history for counter-espionage.

The business meeting followed with the nominating committee report, and it was moved and seconded that the nominees be elected by acclamation, and the following were announced as the newly elected officers:

President—E. R. Harding
Vice-President—L. L. Vaughan
Secretary-Treasurer—F. J. Reed
Board of Governors—E. H. Brandt, Jr., F. E. P. Klages, W. M. Wallace, II (and present officers).

The annual reports were submitted by the various committee chairmen and there were no comments on any.

In view of the wartime conditions, which place an extraordinary demand on the time of those members not called into the armed service, as well as the growing difficulties of transportation, it was realized that attendance at future meetings might be very small; yet it was felt important that these meetings continue. Consequently, it was moved and unanimously passed, that "any By-Law or Rule now in force be suspended for the duration of the present war if the By-Law or Rule shall technically limit or prohibit the transactions of normal or necessary business or proper function of the Chapter, for the preservation of the Chapter. The presiding officer, with the consent of those present at any regular meeting may decide upon the necessity for such suspension."

The meeting was then thrown open to an informal discussion by the 20 members and guests in attendance.

PACIFIC NORTHWEST INDUCTS OFFICERS

May 12, 1942. The regular monthly meeting of the Pacific Northwest Chapter met at 6:30 with 36 members and guests in attendance.

After dinner the minutes of the last meeting were read and approved and the Secretary read his report. The auditing committee gave a report stating that everything was satisfactory and the books were in good shape.

Prof. E. O. Eastwood, president of ASHVE, told about his last trip East and expressed his appreciation to the local chapter for the interest and communications sent him. Mrs. Churchill, a nurse from London, England, was introduced and told of some of her experiences during raids. She gave a very interesting talk, giving a very vivid picture of what happens during an air raid.

Pres. F. J. Pratt thanked the program committee for the work they had done this year and presented H. T. Griffith, the incoming president, with a lapel pin, and a gavel as the official token of the presiding officer.

President Griffith made a short speech and called on the other officers to say a word or two. A standing vote of thanks was given the retiring president for his work during the past year. With no further business the meeting adjourned.

In Memoriam

John F. Hale

Whereas, the Officers and Council of the American Society of Heating and Ventilating Engineers learn with sincere sorrow of the death on May 29, 1942 of their beloved fellow member and past president, John F. Hale, and

Whereas, the Society has lost one of its staunch leaders who guided it during two of its early years of development, encouraged and participated in the organization of its first local chapter and has witnessed its progress to a position of world wide influence, and

Whereas, his ability as an engineer and executive has earned a wide circle of friends and his generosity and deep sense of service to his fellowmen has aided in the professional advancement of many to whom he gave wise advice and counsel,

Therefore, Be it Resolved, that we, the members present at the Semi-Annual Meeting 1942 in St. Paul, Minn. hereby extend our deepest sympathy to his sorrowing family and pay tribute to his kindly, sympathetic and friendly nature which has endeared him to all of our members, and

Be it Further Resolved, that this resolution of condolence be recorded in the proceedings of the Society and a copy sent to his family, so that they may know in what great esteem his memory is held.

J. Irvine Lyle

Whereas, the Officers and Council of the American Society of Heating and Ventilating Engineers learn with profound sorrow of the death on June 7, 1942 of its beloved fellow member and past president, J. Irvine Lyle, and

Whereas, in his passing the Society has lost one of its most outstanding members, whose vision, unselfish devotion and untiring labors as an officer and committeeman in establishing our research laboratory, have left a lasting impression on the development of the Society and the advancement of the art of heating, ventilating and air conditioning, and

Whereas, he was a pioneer in his profession, an engineer of proved ability, a brilliant leader and a loyal friend, whose many fine traits of character endeared him to all of our members,

Therefore, Be it Resolved, that we, the members present at the Semi-Annual Meeting 1942 in St. Paul, Minn. hereby express our deepest sympathy to his family in their sorrow and acknowledge our great debt for his liberal contributions that have brought honor and prestige to the Society, and

Be it Further Resolved, that this resolution be inscribed in the proceedings of the Society and a copy presented to his family so that they may know the high esteem in which his memory is held.

W. L. FLEISHER, Chairman
E. K. CAMPBELL
J. F. COLLINS, JR.

June 15, 1942.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 17 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by Sept. 15, 1942, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
BAECHLIN, ALFRED C., JR., Engr., Western Electric Co., Bayonne, N. J.	D. T. Buck A. R. Mumford	W. A. Janos Paul Lindholm (*Non-member*)
BECKER, ROY F. J., Pres., Oil Burner Service Co., Minneapolis, Minn.	C. O. Carlson E. L. Knowles	H. M. Betts William McNamara
BEMIS, WILFRED A., Sales Engr., N. O. Nelson Co., St. Louis, Mo.	L. R. Szombathy D. F. Hyde	F. E. Carlson J. S. Malone
BROWN, WILLIAM L., JR., Co-Owner, Brown Bros. Plumbing & Heating Co., Durham, N. C.	G. F. Altemueller F. J. Reed	M. F. Wooten, Jr. C. E. Petty
BRYAN, WILLIAM L., JR., Research Engr., York Ice Machinery Corp., York, Pa.	W. E. Zieber G. L. Tuve	G. B. Priester E. S. Theiss
CALNAN, DANIEL J., Field Repr., Electric Furnace Man, Inc., New York, N. Y.	F. L. Hilder C. H. Hall	H. F. Eastwood R. T. Demarest
DAVIS, CLEMANT A. L., Department Mgr., Sales Engrg., John H. Kitchen & Co., Kansas City, Mo.	F. A. Sheppard J. H. Kitchen	W. L. Cassell F. A. Kitchen
EICHOLTZ, MERYL V., Dist. Mgr., Ilg Electric Ventilating Co., Wauwatosa, Wis.	J. H. Volk A. R. Podolske	A. C. King J. S. Jung
FULMOR, IRA P., Owner, Air Conditioning Co. of Southern California, Los Angeles, Calif.	Harrold English H. B. Lauer	A. J. Hess E. H. Kendall
HORSBURGH, BALFOUR J., Dist. Repr., Johnson Temperature Regulating Co. of Canada Ltd., Montreal, Que., Canada.	G. L. Wiggs C. W. Johnson	L. A. Hood A. E. Watts
KAYAN, CARL F., Asst. Prof. Mech. Engrg., Columbia University, New York, N. Y.	C. E. Lucke John Everetts, Jr.	Francis Hodkinson John James
MEYERS, CARL F., Sales & Engrg., Coblentz Equipment Co., Erie, Pa.	William Goodman S. W. Strouse	G. H. Anderegg Herman Seelbach, Jr.
O'DANIEL, JAMES A., Prop., Maple City Furnace Co., Monmouth, Ill.	H. A. Soper R. P. Whitmer	W. M. Romine (*Non-member*) D. M. McMichael (*Non-member*)
OLSON, ERLING O., Service Engr., Oil Burner Service Co., Minneapolis, Minn.	C. O. Carlson E. L. Knowles	H. M. Betts William McNamara
RICHARDSON, WALTER A., Engr., Thorn & Hoddle Ltd., London, S. W. 1, England.	W. L. Swain G. R. Jackson	H. C. Barratt (*Non-member*) J. B. Weed (*Non-member*)
SCHUSTER, PAUL H., Chief Heating Inspector, Corps of Engineers, Post Utilities, Camp Chaffee, Ark.	W. A. Russell P. C. Leffel	M. G. Tieman C. E. Kuhn
TANZER, GUY J., Hotel Wellington, N. Y.	S. R. Apt T. F. Shelldrop	E. O. Marty Barnett Braslow (*Non-member*)

Candidates Elected

In the past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BURNS, FRED C., Mgr., Kewanee Boiler Corp., Kansas City, Mo. (*Reinstatement*)

DUPUIS, JOSEPH E. R., Branch Mgr., Trane Company of Canada, Ltd., Montreal, Que., Canada (*Reinstatement*)

MOLER, WILLIAM H., Dist. Engr., Governair Corp., Dallas, Tex. (*Reinstatement*)

PEARCE, EDWARD A., Engr. & Chief Draughtsman, E. Wingfield-Bowles & Partners, Northwood, Middlesex, England.

SALTER, STANTON W., Heating Specialties, Engineering Equipment Co., Ltd., Montreal, Que., Canada.

SHELBY, ALEXANDER W., Engr. & Partner, Shelby-Skipwith, Inc., Memphis, Tenn.

ASSOCIATES

BEERS, LOUIS N., Heating Engr., W. T. Andrew Co., Detroit, Mich.

BOWEN, LEROY F., Gate City Petroleum Co., Kansas City, Mo.

FARBMAN, LEONARD, Engr., M. Farbman & Sons, Inc., New York, N. Y. (*Reinstatement*)

GILLILAND, LESLEY L., Operating Engr., Gadsden Ordnance Plant, Gadsden, Ala.

WIGHT, EDWARD A., Prof. of Library Education, Peabody College, Nashville, Tenn.

JUNIOR

NATION, OSLIN, Assoc. Engr., U. S. Engineering Defense Div., Denison, Texas.

Officers, Council and Committees

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

51 Madison Ave., New York, N. Y.

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First Vice-President.....M. F. BLANKIN
Second Vice-President.....S. H. DOWNS
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Two Years: A. P. KRATZ, W. A. RUSSELL, L. P. SAUNDERS, C. TASKER.

One Year: J. F. COLLINS, JR., W. L. FLEISHER, E. N. MCDONNELL, T. H. URDAHL, C.-E. A. WINSLOW, F. C. MCINTOSH, *Ex-Officio.*

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Membership—W. A. Russell, *Chairman*, M. F. Blankin, B. M. Woods.
Standards—S. H. Downs, *Chairman*, L. G. Miller, C. Tasker.
Meetings—A. P. Kratz, *Chairman*, L. P. Saunders, T. H. Urdahl.

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SPECIAL COMMITTEES

Admission and Advancement—Earle W. Gray, *Chairman* (*one year*); E. P. Heckel (*two years*), T. T. Tucker (*three years*).

ASHVE-*ASTM-ASRE-NRC Committee on Thermal Conductivity:* F. C. Houghten, *Chairman;* C. B. Bradley, H. C. Dickinson, R. H. Heilman, E. R. Queer, F. B. Rowley, T. S. Taylor and G. B. Wilkes.

ASHVE-IES Joint Committee on Lighting and Air Conditioning—H. M. Sharp, *Chairman;* W. R. Beach, B. C. Candee, W. G. Darley, C. L. Kribs, Jr., P. M. Rutherford, Jr.

Chapter Relations—J. F. Collins, Jr., *Chairman;* Lincoln Bouillon, M. M. Rivard.

Constitution and By-Laws—Albert Buenger, *Chairman*, L. T. Avery, R. H. Carpenter.

Committee on Code for Testing Surface Coils for Heating and Cooling—C. A. McKeeman, *Chairman;* Tom Brown, E. L. Hogan, H. F. Hutzel, L. E. Moody, A. F. Nass, S. F. Nicoll, M. Noble, L. P. Saunders, and D. C. Wiley.

Committee on Safety Regulations for Heating, Ventilating and Air Conditioning Systems—N. A. Hollister, *Chairman;* F. H. Buzzard, B. F. McLouth, G. P. Nachman, and C. H. Randolph.

Committee on ASHVE Code for Testing Air Cleaning Devices—John Howatt, *Chairman;* O. W. Armspach, J. L. Blackshaw, R. S. Dill, S. P. Eagleton, S. R. Lewis, Arthur Nutting, G. W. Penney, F. B. Rowley, J. H. Waggoner, and Dr. Leonard Greenburg, *Ex-Officio.*

Guide Publication—A. J. Offner, *Chairman*, P. D. Close, S. Konzo, C. S. Leopold, G. L. Tuve.

F. Paul Anderson Award—M. F. Blankin, *Chairman*, W. H. Carrier, J. D. Kroeker, J. F. McIntire, F. B. Rowley.

Joint Committee on Standards for Residence Heating—L. E. Seeley, *Chairman;* R. S. Dill, S. H. Downs, H. L. Dryden, J. G. Eadie, H. C. Meyer, Jr., R. K. Thulman, T. H. Urdahl, and H. Vermillyea.

Joint Committee to Study Uniform Methods of Heat Loss Calculation—P. D. Close, *Chairman;* A. P. Kratz, J. P. Magos, G. P. Nachman, A. F. Nass.

Joint Committee on Weather Statistics—J. F. Collins, Jr., *NDHA, Chairman;* F. H. Dewey, *OBI*, C. M. Humphreys, ASHVE, S. Konzo, *NWAHACA*, Raymond Little, *AGA*, Dr. E. Dillen Smith, *U. S. Weather Bureau.*

Publication—James Holt, *Chairman* (*one year*); C. H. B. Hotchkiss (*two years*), J. H. Walker (*three years*).

War Service Committee—B. M. Woods, *Chairman*, W. A. Danielson, W. L. Fleisher, E. Holt Gurney, Thornton Lewis, A. C. Willard.

NOMINATING COMMITTEE 1942

Chapter	*Representative*	*Alternate*
Atlanta	T. T. Tucker	A. H. Koch
Cincinnati	C. E. Hust	Albert Buenger
Connecticut	L. E. Seeley	Stanley Hart
Delta	L. V. Cressy	J. S. Adair
Golden Gate	**C. E. Bentley**	
Illinois	M. W. Bishop	E. M. Mittendorff
Iowa	Perry LaRue	F. E. Triggs
Kansas City	M. M. Rivard	W. A. Russell
Manitoba	R. L. Kent	I. McDonald
Massachusetts	J. W. Brinton	Earl G. Carrier
Michigan	J. S. Kilner	M. B. Shea
Minnesota	R. E. Backstrom	N. D. Adams
Montreal	A. M. Peart	E. W. Twizell
Nebraska	Henry Kleinkauf	W. R. White
New York	Joseph Wheeler, Jr.	H. H. Bond
North Carolina	W. M. Wallace II	F. J. Reed
North Texas	R. K. Werner	J. A. Bishop
Northern Ohio	C. A. McKeeman	C. M. H. Kaercher
Oklahoma	J. H. Carnahan	E. F. Dawson
Ontario	D. O. Price	H. R. Roth
Oregon	E. E. Carroll	B. W. Farnes
Pacific Northwest	H. T. Griffiths	M. J. Hauan
Philadelphia	H. H. Mather	
Pittsburgh	C. M. Humphreys	H. Lee Moore
St. Louis	C. F. Boester	I. H. Carter
South Texas	**A. M. Chase, Jr.**	**R. M. Spencer**
Southern California	A. J. Hess	H. H. Bullock
Washington, D. C.	F. A. Leser	T. H. Urdahl
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